Veterinary and Comparative Ophthalmology,

BY

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DEDICATED

To the Memory of the Translator's Friend,

The Late WILLIAM HUNTING, F.R.C.V.S.,

Consulting Veterinary Surgeon to the London County Council,

In appreciation of the close friendship and many acts of kindness shown him during the last quarter of a century, and for urging him to undertake the Translation of this work for the benefit of the veterinary profession in English speaking countries.

TRANSLATOR AND EDITOR'S PREFACE.

Owing to the many nebulous or erroneous ideas until quite recently held regarding the Anatomy, Physiology and Pathology of the Eye of Domesticated Animals, the Translator and Editor offers no apology for presenting this work on Veterinary and Comparative Ophthalmology to English-speaking veterinary students and practitioners.

The need of such a work, which unless one had a knowledge of the Continental languages would remain a closed chapter, has long been felt, because although there are many excellent treatises on human ophthalmology these are often misleading to the student of animal medicine.

This edition, which has been brought up to date and further illustrated by Dr. Nicolas, who, owing to his special predilections, has made a long continued and careful study of the subject, has also been added to, both in illustrations and text, by the Translator and is not merely a translation of the original work.

For all errors of omission and commission which have crept in, as pointed out in the corrigenda at the end of the book, and also for not following the type of the original text, the Translator takes full responsibility.

His best thanks are due to Dr. Nicolas, who not only obligingly consented to the work being translated but has taken the trouble to supply additional information and illustrations, most of which were from his own pencil, in order to bring the book up to date.

To Major-General Fred Smith, C.B., C.M.G., F.R.C.V.S., F.I.C., late Director-General of the Army Veterinary Service, and Professor James Macqueen, F.R.C.V.S., Professor of Surgery at the Royal Veterinary College, London, the Translator offers his sincere thanks and gratitude for their critical reading of the proofs, offering suggestions and supplying additional facts. The former gentleman for many years stood alone in his

endeavours to encourage ophthalmology among veterinary surgeons in the United Kingdom, and until his lucid and careful writings on the Ophthalmoscope, Cataract, and State of Refraction of the Horse's Eye appeared in the *Journal of Comparative Pathology and Therapeutics* and the *Proceedings of the Royal Society*, very little work having any scientific and practical value was done in this country.

The Translator is deeply indebted to Sir John M'Fadyean, M.B., B.SC., M.R.C.V.S., LL.D., Principal of the Royal Veterinary College, London, for his kind permission to copy the figure on page 369 from General Smith's article on Cataract in the *Journal of Comparative Pathology and Therapeutics;*

To Herr Wilhelm Braumüller, Publisher, Vienna, for kindly granting permission to reproduce the figures on pages 359 and 360 from the late Dr. Joseph Bayer's masterly work on "Augenheilkunde";

To Mr. Alfred Joseph Sewell, M.R.C.V.S., Veterinary Surgeon to His Majesty King George V, for the use of the beautiful coloured plate, from the pencil of the distinguished ophthalmological artist Mr. Arthur W. Head, illustrating the background of the eye in tubercular chorioiditis in the cat;

To Mr. Herbert A. Lake, M.R.C.V.S., M.R.C.S., L.R.C.P., for kindly drawing the figures on pages 109, 110, 475, 476, 485, 497;

To Mr. Vernon Stokes, Artist, for his excellent drawings on pages 401, 481, 494;

To Mr. Sydney A. Sewell, Pathological Artist, for making several beautiful drawings illustrating various conditions of the eye.

Finally, the Translator thanks Messrs. Allen & Hanbury, Ltd., 48 Wigmore Street, W., Messrs. Maw, Son and Sons, 7 to 12 Aldersgate Street, E.C., and Messrs. Davidson & Co., 29 Great Portland Street, W., for the loan of blocks illustrating surgical instruments.

HENRY GRAY.

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AUTHOR'S PREFACE.

In writing this book, which contains facts and scarcely any theory, it has been my object to present the state of our knowledge of the ophthalmology of animals in as lucid and concise but, at the same time, in as complete a manner as possible.

The diseases of the eye and its appendages, the methods of examination in everyday practice, and, in fact, all those points more immediately interesting to the practitioner have occupied the bulk of its pages and are printed in large type. I have, however, not neglected the more scientific side, such as physics, anatomy, physiology, etc., which the newer they may seem to appear the more interesting they become. This I have, as a rule, restricted to small type.

Strictly speaking it is a work on *veterinary* ophthalmology in which I have made use of only those authenticated facts observed in animals, and then only after they have appeared to me to have been carefully studied. When I have had recourse to data furnished by human ophthalmology this has always been done from a *comparative* point of view.

Certain affections remaining obscured, as much in their manifestations as in their causes, could only be rendered lucid by this reunion. Moreover, the pathology of nervous diseases of animals could only be made clear by regarding them from the standpoint of the significance of their ocular symptoms which, although frequently encountered in veterinary medicine, generally remained, so far as their diagnostic interpretation was concerned, fruitless. I have, however, taken care to emphasize all that which relates exclusively to man as I have also emphasized that which belongs more especially to each animal species.

This little treatise, whose origin dates back to the ophthalmoscopic studies pursued with Dr. C. Fromaget and to those on the diseases of the uveal tract of the horse, which next occupied my attention, took its schematic form in 1901, at the time when Principal Veterinary Surgeon Jacoulet—whom I have much pleasure of thanking here—did me the honour of calling upon me to deliver a course on ophthalmology to the veterinary probationers at Saumur. This afforded me, in

fact, the opportunity of putting into form my personal researches in the numerous bibliographic documents, which I had for some time been accumulating.

I found in our annals a number of interesting facts, but it is in reality in the *Zeitschrift für vergleichende Augenheilkunde* that veterinary ophthalmology should have its scientific basis. This journal of comparative ophthalmology, of which only seven small volumes appeared from 1882 to 1903 before it ceased publication,* was founded and edited by two masters of human ophthalmology, Professors Berlin and Eversbusch, who were joined later by professors of veterinary schools on the other side of the Rhine, among others J. Bayer, contains much valuable information, and without diminishing the credit of those who have written before on the diseases of the eyes of animals, one may say that veterinary ophthalmology originated with that journal.

That great monumental work in the form of the *Encyclopédie française d'ophtalmologie* has afforded me numerous, more especially experimental, facts of which I have profitably availed myself whenever they have appeared to me to be capable of shedding some light on questions on which careful clinical observations are wanting.

In trying thus to bring together everything that could serve for building up such a new science, as is veterinary ophthalmology, it has been my ambition to fill up that lacuna which has existed in our literature since 1824 when Urbain Leblanc's work appeared.

I leave it to my confrères to say whether I have succeeded in my endeavours to be of use to them.

I am deeply indebted to Professor Lagrange and Dr. Valude, editors, and M. Doin, publisher, of the *Encyclopédie française d'ophtalmologie* as well as to Messrs. Cadiot and Almy for having so willingly placed some of their beautiful blocks at my disposal; and my thanks are due to my courteous publishers, MM. Asselin and Houzeau.

E. NICOLAS,

EPINAL, (VOSGES).

* [This has since been replaced by the creation of the *Archiv für vergleichende Augenheilkunde*.—TRANS.]

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ABBREVIATIONS USED IN OPHTHALMOLOGY.

Acc. Accommodation.
As. Astigmatism.
E. Emmetropia.
M. Myopia.
H. Hypermetropia.
Hm. Manifest hypermetropia.
Hl. Latent hypermetropia.
Pr. Presbyopia.
p. Punctum proximum or near point.
r. Punctum remotum or remotissimum or far point.
p.l. Perception of light.
T. Tension of the eyeball.
F. Field of vision.
V. Acuteness of vision or power of distinguishing obstacles.
B.v. Binocular vision.
A.C. Anterior chamber.
P.C. Posterior chamber.
Cb. Ciliary body
Cp. Ciliary process.
Ch. Chorioid.
Cn. Cornea.
Cnj. Conjunctiva.
Cpn. Corpora nigra.
C.L. Crystalline lens.
Ir. Iris.
M.n. Membrana nictitans
M.l. Macula lutea.
O.P. Optic papilla or disc.
P. Pupil.
t.l. Tapetum lucidum.
t.n. Tapetum nigrum.
Rt. Retina.
Sc. Sclera or sclerotic

m. metre. *cm.* centimetre. *mm.* millimetre. *gm.* gramme.

D. Dioptre or the Dioptric Unit of the metrical system in measuring lenses; a lense whose focal length is 1 metre (39½ inches).

Symbols. + A convex or positive lense.
− A concave or negative lense.

VETERINARY AND COMPARATIVE OPHTHALMOLOGY.

CHAPTER I.

GENERAL REMARKS ON THE ANATOMY OF THE EYE.

The anatomical parts with which ophthalmology is concerned are the eyeball, or the essential organ of vision, and the appendages of the eye, *i.e.* the cavity which contains the eye, the eyelids which protect it, the muscles which move it, and the lacrimal apparatus which constantly moistens its transparent portion.

We are only concerned here with the eyeball, viewed as a whole, particularly with regard to the qualities which make it a physical apparatus, and which must be understood in the study of Dioptrics. The anatomy and physiology of each of the parts constituting the visual apparatus will be discussed at the beginning of the chapters dealing with their Pathology. This arrangement, though generally adopted, has the disadvantage of splitting up the Anatomy which should form a whole, but on the other hand, it has the advantage of being less wearisome to the reader, and of offering him in small sections, facts and ideas which, under other circumstances, he might be tempted to omit as being superfluous.

The Eyeball.

The eyeball is made up of membranes which are associated to form a hollow envelope, closed at all points, but allowing light to pass through a window—the cornea, and of transparent media which fill the cavity.

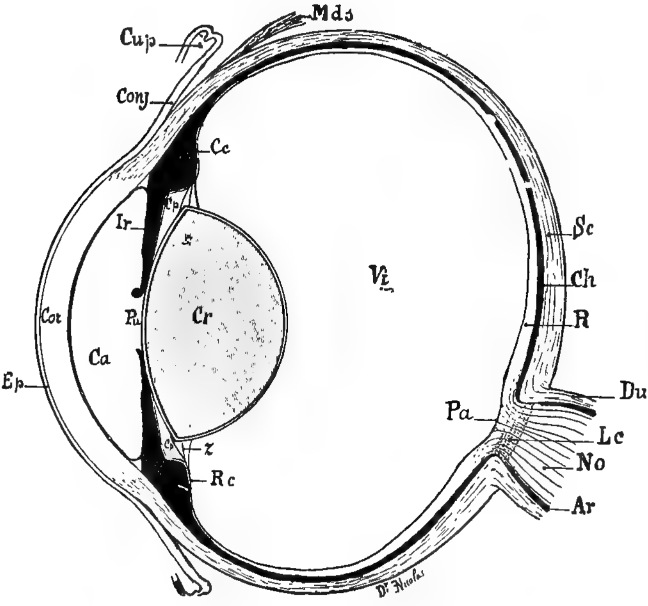


Fig. 1.—Eye of Horse, vertical section.

Ca., Anterior chamber. *Cc.*, Ciliary body. *Ch.*, Choroid. *Conj.*, Conjunctiva. *Cor.*, Cornea. *Cp.*, Posterior chamber. *Cr.*, Lens with its enveloping membrane. *Cup.*, Conjunctival sac. *Du.*, Dura mater. *Ep.*, Epithelial layer of the Cornea. *Ir.*, Iris. *Lc.*, Lamina cribrosa. *Mds.*, Sup. Rectus Muscle. *No.*, Optic Nerve. *Pa.*, Optic papilla. *Pu.*, Pupil. *R.*, Retina. *Rc.*, Portion of the Retina covering the Ciliary Body and the Iris. *Sc.*, Sclerotic. *Vi.*, Vitreous humour. *Zz.*, Zonula of Zinn.

Fig. 1 and the following table give a good idea of the disposition of these parts :

Membranes.	External ...	Fibrous ... ... / Protective ...	Opaque ...	*Sclerotic.*
			Transparent.	*Cornea.*
	Middle	Vascular ... / Pigmentary ... / Nutrient ...	Uveal Tract.	*Iris.* / *Ciliary body* / *Choroid.*
	Internal	Nervous, sensitive to rays of light		*Retina.*
		Connected to the brain by		*Optic nerve.*

Transparent Media.	Anterior ...	Liquid	*Aqueous humour*
	Middle	Solid	*Lens.*
	Posterior ...	Vitreous	*Vit. humour*

The Volume of the eyeball varies in the same species and naturally from one species to another. According to Sömmering the eyeball of the Horse (or that of the Ostrich), is the largest among terrestrial animals.* It is larger than that of the Elephant or Rhinoceros. According to the studies of Emmert it appears that the domesticated animals can be classified according to the absolute volumes of their eyeballs; Horse (38 to 50 c.c.); Ox, Calf, Sheep, Pig, Dog, Cat (4·5 to 5 c.c.); but the volume of the eye in comparison to the body weight gives the following (decreasing) order: Cat, Rabbit, Dog, Sheep, Calf, Horse, Man, Cow, Pig, Ox. In the same species small animals have relatively the largest eyes *i.e.*, the volume of the eye increases more rapidly than the weight of the body. "Large eyes giving a very clear image on the retina are found in animals which move rapidly and have consequently need of a very quick, clear vision; this is the case in birds, particularly those of nocturnal habits, and in carnivora." (Kalt.) Birds have very large eyes in proportion to their size. The weight of the eyeball in the Horse varies from 45 to 60 grammes, in the Dog it is 4 to 8 grammes (Koschel).

* The eye in Cetaceans is the largest known. Matthiessen gives the following measurements for the *Megoptera boops*:—transverse diameter, 92 mm., vertical diameter, 88 mm., antero-posterior diameter, 68 mm.

The form of the eyeball is that of a spheroid with more or less unequal axes—those measured being the transverse, vertical, and antero-posterior. The average dimensions of these axes established by Bayer, from figures of different authors (Sömmering, Matthiessen, Berlin, Koschel, Emmert, Nicolas and Fromaget, Dexler, and Bayer), are given in the following table to which have been added the corresponding measurements in man :—

Animal.		Axis.		
		Ant.-post'r. mm.	Vertical. mm.	Transverse. mm.
Horse	...	43.68	47.63	48.45
Ox	...	35.34	40.82	41.90
Sheep	...	26.85	30.02	30.86
Pig	...	24.60	25.53	26.23
Dog	...	21.73	21.34	21.17
Cat	...	21.30	20.60	20.55
Man	...	24.60	23.50	23.90

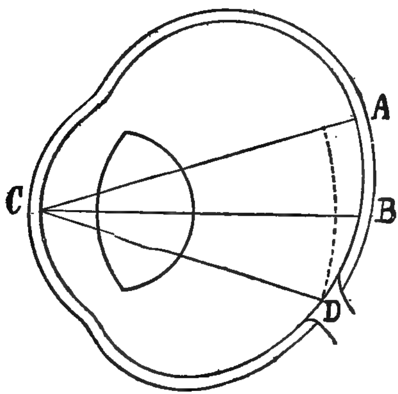


Fig. 2.

The extreme dimension of the antero-posterior axis of the Horse are 45 mm. (Matthiessen), 42 mm. (Nicolas and Fromaget).

The eyeball is flattened from before to behind in Herbivora, and is almost spherical in Carnivora.

In Ruminants, the flattening is regularly distributed over the whole of the posterior face, while in the Horse it is parti-

cularly pronounced on the posterior face of the inferior hemisphere. In front, the spheroid is a little deformed from the jutting out and the asymmetrical position of the cornea, which approaches nearer to the inferior than the superior pole. This asymmetry is general in Mammalia, but is particularly marked in the horse.

From these facts it follows that the eye of the horse has an almost spherical shape as in shown in fig. 2. It also shows that the distance, from the centre of the cornea to the different points of the posterior wall are unequal CA > CB > CD. This fact has to be taken into account in the determination of refraction. (Nicolas and Fromaget).

In poultry the eyeball is very flattened from before to behind, and resembles a half-spherical cup closed in front by a flattened covering.

The Cornea. The radii of curvature have been determined by different authors (Matthiessen, Berlin, Koschel, Klingsberg, Dexler, Mœnnich, Wolfskehl, Bayer). The following are the averages of their figures given by Bayer, from whose work the following table is quoted. The measurements are those of Koschel.

Radii of curvature and dimensions.

Animal.	Radii of Curvature. (Av. of authors' figs.)		Dimens. in straight line. Koschel.	
	Vertical. mm.	Horizontal. mm.	Breadth. mm.	Height. mm.
Horse ...	16.57	17.94	33.10	25.80
Ox ...	15.21	16.43	30.50	23.20
Sheep ...	11.95	11.37	22.40	15.40
Pig ...	10.60	11.00	17.70	14.70
Dog ...	8.50	9.30	16.30	15.25
Cat ...	8.90	8.40	17.00	16.00
Man ...	7-8	8.40	12.00	10.00

As a rule the cornea is more curved along its vertical than along its horizontal meridian, even in man, and the diameters are not equal, the horizontal being always the greater.

LENS.

SPECIES.	VOLUME. (Emmert).	PROPORTION between vol. of lens = 1 to vol. of eye (Emmert).	WEIGHT (Koschel).	ANTERO-POSTERIOR AXIS. Average of Authors' figures.	DIAMETER. Average of Authors' figures.	RADII OF CURVATURE. Average Figures. Anterior Face.	Posterior Face.
	c.c.		Grammes.	mm.	mm.	mm.	mm.
HORSE	2.8 - 3.5	16.3 / 12.1 (Matthiessen)	5.2 / 3.5 (Emmert).	12.8	19.4	17.0	11.0
OX	2.2	14.5	4.3 / 2.3	13.0	18.4	12.8	10.0
PIG	.5 -.8	12.4	1.55	13.0	18.4	12.8	10.0
DOG	.5	10.2	1.07 - 1.55	7.4	10.7	6.2	5.5 (Koschel)
CAT	.5	9.8	1.47	7.6	9.7	6.3	6.7 (Koschel)
RABBIT	.5	10.0	1.47	7.6	9.7	6.3	6.7
MAN	.2	18.0	.25	4.5 - 5.0	9.10	10.0	6.0

Lens. In the accompanying table the measurements of the lens are given.

The direction of the eyes depends on that of the orbits. Whilst in man and monkeys they have an almost parallel and antero-posterior direction, they are more and more divergent in Carnivora, Herbivora, and Birds, and in that order.

As a comparative measure of this direction, the angle of intersection of planes drawn tangentially to the base of each orbit may be taken. Always open behind, this angle is about 145 to 150° in Man (Emmert); 168° in the Ourang-Outang (Leuckart); and, according to Müller, 105° in the Cat: 84 to 92° in the Dog, 62° in the Pig, 60 to 62° in the Ox, 42 to 45° in the Horse, and only 30° in Birds, in which the eyes are placed quite laterally.

Koschel, of the Berlin School, has given the direction of the ocular and orbital axes from precise measurements, which are tabulated below. The orbital axis is the line going from the optic foramen to the centre of the orbital opening, and the ocular axis is the line passing through the centre of the cornea and lens. The table shows that the ocular axes are more divergent than the orbital.

Direction taken by the Orbital and Ocular Axes.

Animal.	Angle formed by ocular axis.	Angle formed by orbital axis.	Angle between the ocular and orbital axis.
	deg.	deg.	deg.
Horse ...	137	115	11
Ox ...	119	94	13
Sheep ...	134	129	2
Pig ...	118	85½	17
Dog ...	92.5	79	7
Cat ...	77	49½	13
Man (Emmert).	10	42	22

Space between the Eyes and the Orbits. Berlin for the eyes, and Koschel for the orbits, give the following figures:

Animal.	Space between centre of Pupils (Berlin). cm.	Space between centre of Orbits (Koschel). cm.
Elephant ...	49.00	—
Horse	19.60	15.54
Ox	18.00	16.03
Sheep	8.00	7.38
Pig	—	6.58
Cat	—	1.77
Man	6.00	—

Dimensions and volume of the Orbit. The following data are given by Koschel for the dimensions and by Dexler for the comparative volume of the eyeball of the orbit.

Animal.	Breadth of Opening.	Height of Orbit.	Length of Orbital Axis.	Volume of Globe. / Volume of Orbit.
Horse ...	59.4	66.1	85.6	1 : 2.5
Ox ...	63.5	71.6	101.3	1 : 6.0
Sheep ...	37.2	41.2	46.5	1 : 1.6
Pig ...	37.0	40.7	51.7	1 : 1.4
Cat ...	24.4	27.9	30.0	—
Man ...	40.4	40.9	45.5	—

In the horse and ox the above figures are the averages of twenty different measurements.

Development of the Eye.

Some ideas on the embryology of the eye are necessary in order to understand the genesis of congenital anomalies.

The eye is a product of the ectoderm and of the mesoderm. When the three cerebral vesicles are formed—swellings in the invaginated groove in the ectoderm—there form on the lateral aspect of the anterior vesicles small swellings which are the first outlines of the organ of vision. These are known as the primitive ocular vesicles (figs. 3 and 4). In increasing, these vesicles swell in their free portions, but become constricted at their bases to form a pedicle, but they remain hollow and in communication with the cerebral vesicles. Then, in consequence of a phenomenon of cellular proliferation, the swollen

part of the primitive ocular vesicles shows a cup-like depression on its summit—in other words it becomes invaginated to give birth to two new cavities, and secondary ocular vesicles. These cavities are prolonged in the form of grooves on the inferior edges of the pedicles in such a way that the secondary ocular vesicle is not only open in front but also behind.

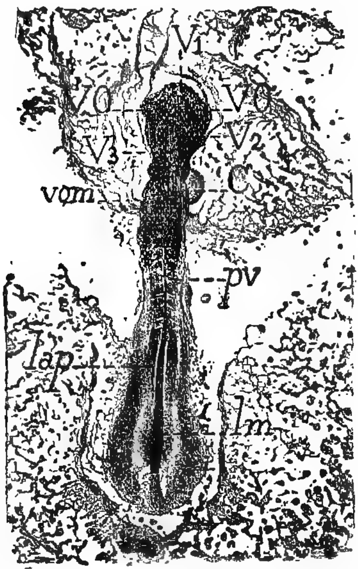


Fig. 3.—Dorsal surface of embryo of fowl. Middle of second day. (By 18 diameters).

V1. V2. V3. Anterior cerebral vesicles. Middle cerebral vesicles. Posterior cerebral vesicles. *Vo.* Outline of the primitive ocular vesicles. *C.* The Heart. (Van Duyse, *Encyclopédie française d'ophtalmologie.*)

This lower opening constitutes the fœtal optic cleft, and it is completely closed later on. Lack of coaptation of these edges gives rise to different forms of typical Colobomata, which will be dealt with under the head of congenital anomalies. (See Figs. 5, 6, 7).

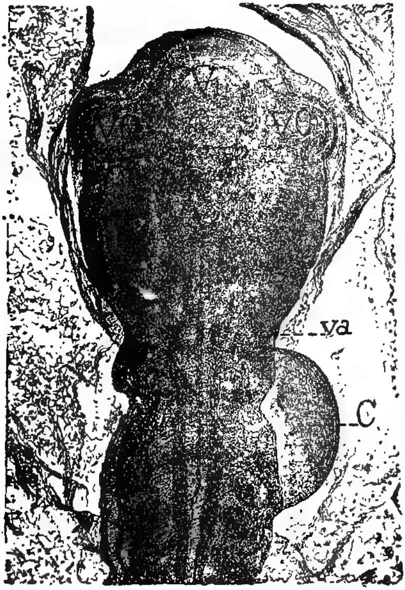
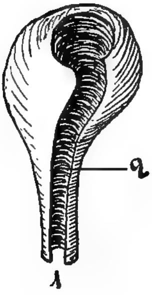
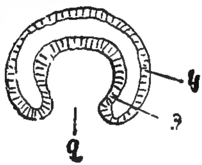


Fig. 4.—Details of the cephalic extremity of embryo in fig. 3.





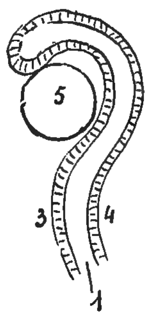


Fig. 5—Secondary ocular vesicle (Legrange).

Fig. 6.—Frontal section of the vesicle.

Fig. 7.—Antero-posterior section of the vesicle.

1. Furrow-like groove.
2. Foetal optic cleft.

2. Ocular fissure.
3. Invaginated layer of the vesicle.
4. Non-invaginated layer of the vesicle.

5. The lens.

The two layers of the secondary ocular vesicle form the retina proper, as well as the posterior epithelial layer of the ciliary body *(pars ciliaris retinæ)*, and of the iris *(pars iridica retinæ)*; while the layers of the pedicle form the optic nerves and the optic tracts. The retina is therefore a direct outgrowth of the brain.

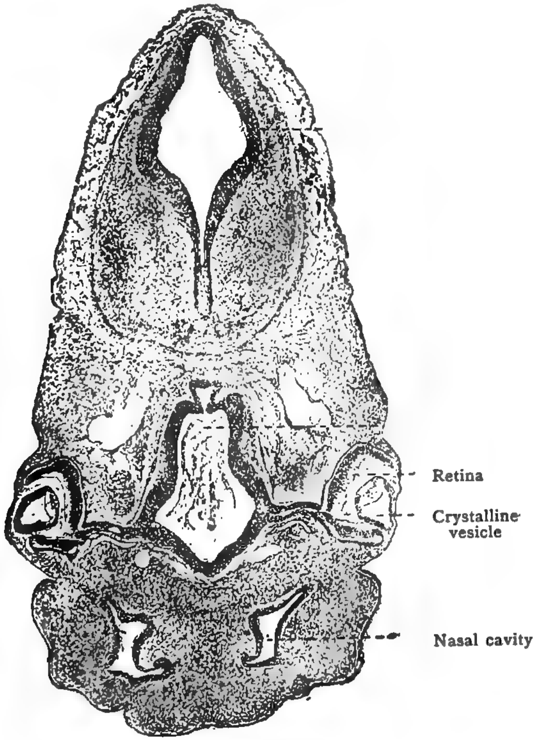


Fig. 8.—Horizontal section (slightly oblique) of the cephalic extremity of the brain of an embryo calf (14 mm.). (Van Duyse, *Encycl. francaise d'ophtalmologie)*.

At the edge of the anterior opening of the secondary vesicle the recurving ectoderm becomes hollowed out like the finger of a glove, and forms a depression which penetrates to the interior of the vesicle, where it becomes detached, forming the lens. (Figs. 9 and 10).

The mesoderm, which everywhere covers the optic vesicle, becomes condensed on its external face to give birth firstly to the choroid and later to the cornea and sclerotic. At the same time it penetrates into the interior by a fœtal cleft to form the vitreous humour (figs. 10 and 11).

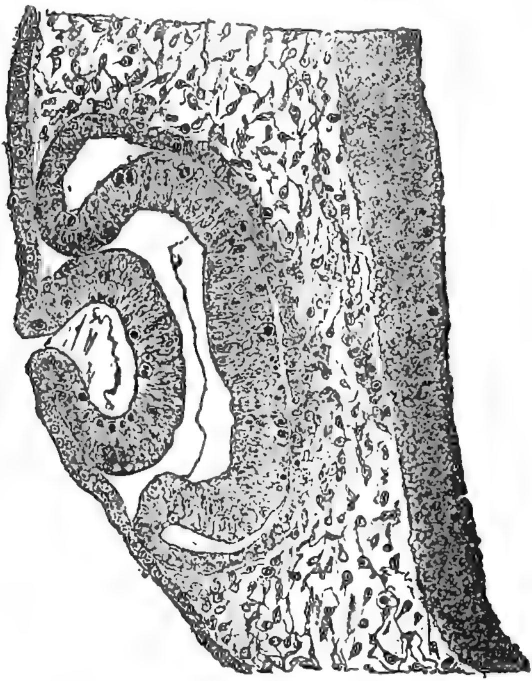


Fig. 9.—Section of the secondary ocular vesicle of a fowl (Van Duyse, *Encycl. fr. d'opht.*).

The eye is now in complete possession of all the materials necessary for its complete development, and the fœtal cleft disappears. Its closure occurs early in mammalia, and takes place from behind forwards, *i.e.*, from the optic nerve to the anterior part of the retina. In birds it persists much longer and constitutes part of the *pecten.*

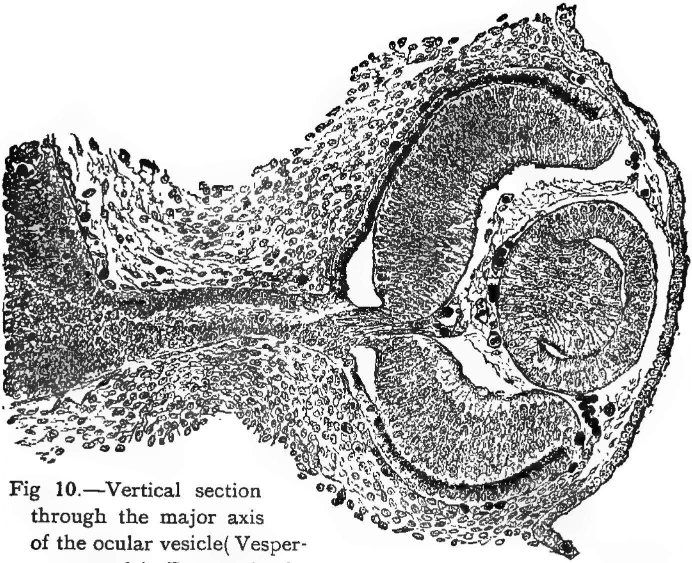


Fig 10.—Vertical section through the major axis of the ocular vesicle(Vesper-ugo noctula). Preparation by Van der Stricht *(Encycl. fr. d'opht.)*.

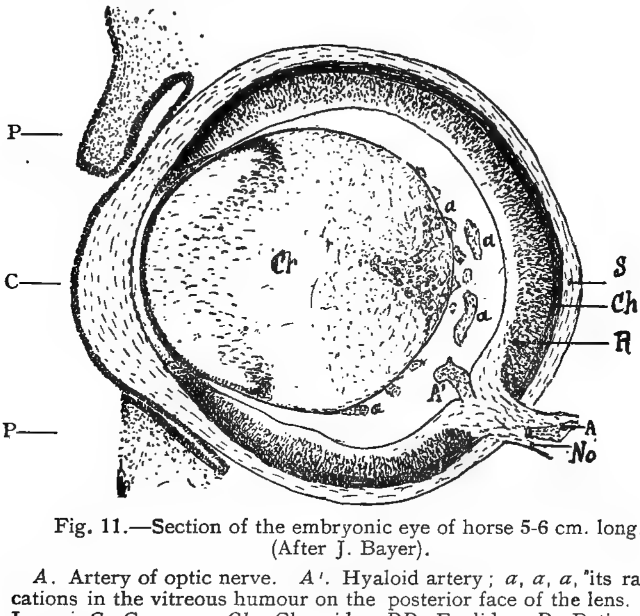


Fig. 11.—Section of the embryonic eye of horse 5-6 cm. long. (After J. Bayer).

A. Artery of optic nerve. *A'*. Hyaloid artery; *a*, *a*, *a*, its ramifications in the vitreous humour on the posterior face of the lens. *Cr*. Lens. *C*. Cornea. *Ch*. Choroid. *PP*. Eyelids. *R*. Retina. *S*. Sclerotic.

The anterior chamber does not yet exist; the iris and ciliary body are not developed; and the eyelids are advancing to meet one another.

The evolution of some parts requiring special attention later on will here be followed. The mesoderm which has penetrated into the groove of the optic pedicle forms the central artery of the retina which, under the name of the hyaloid artery, is prolonged into the interior of the vitreous humour as far as the posterior face of the lens.

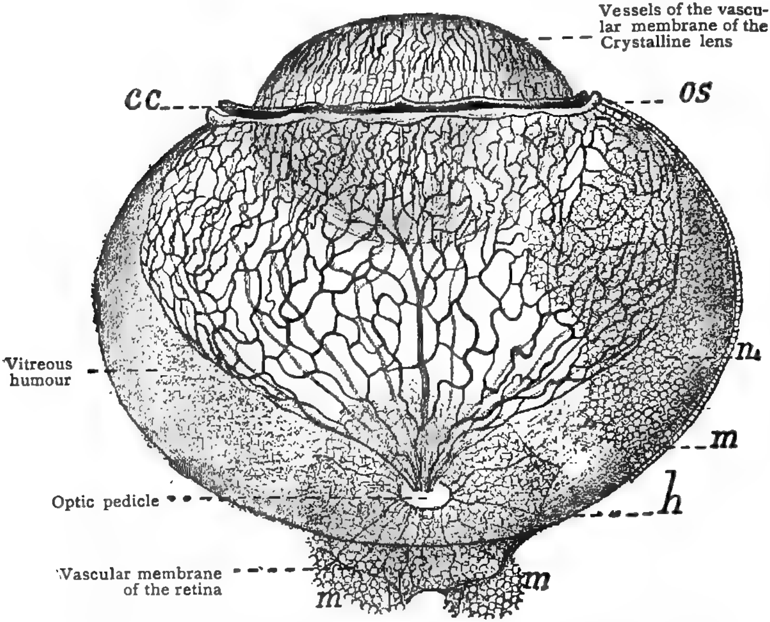


Fig. 12.—Intra-ocular vessels of an embryo of pig (11 cm.) (After O. Schultze, *Encycl. fr. d'opht.*). The ocular tunics are removed except one part of the ciliary body *CC*, and of the retina *OS*, near the ora serrata.

At some distance from this posterior pole the hyaloid artery gives rise to a bundle of branches directed towards the equator of the lens, and forming a vascular cone (Schultze) fig. 12. From the mingling of these vessels a vascular tunic arises which covers the whole of the posterior surface of the lens, and extends beyond the equator on to the anterior face (figs. 13 and 14). The central and peripheral hyaloidal vessels and the vascular lenticular tunic are only temporary fœtal structures.

The mesoderm which envelops the whole of the retina insinuates itselt further between the lens and the re-covering

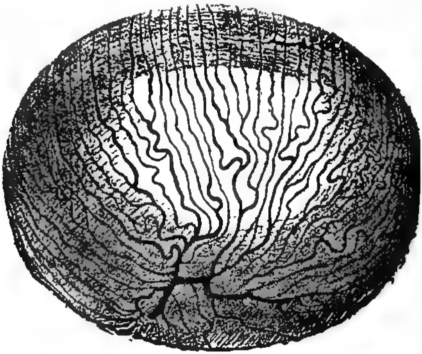


Fig. 13.—Lens of a fœtal horse (44 cm.). Prussian blue injection. (Van Duyse, *Encyl. francaise d'ophtalm.*)

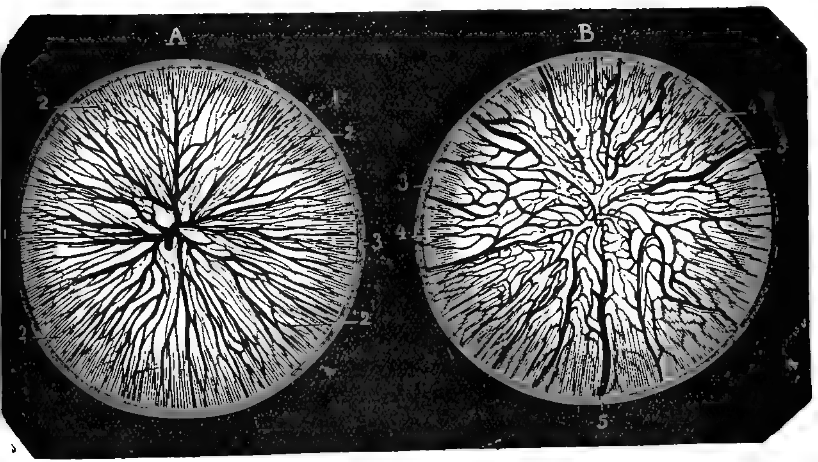


Fig. 14.—Vascular capsule of the lens of a new-born cat: *A*. Seen from its posterior face; *B*. Seen from its anterior face. (Testut. *Encycl. francaise d'ophtalm.*).

1. Section of hyaloid artery. 2. Radiating vessels running towards the edge of the capsule. 4. The same vessels after having turned round the edge. 5. Veins going to the iris. 6. Capsulo-pupillary membrane.

ectoderm to form a complete shell to the eye, which later differentiates itself by splitting into two secondary membranes —the choroid and sclerotic. These membranes are separated by a lymphatic space, the lamina fusca. In front of the lens the mesoderm becomes divided into two planes—one anterior and thick, which becomes the tissue proper of the cornea—the other posterior and very thin which forms the pupillary membrane. The cavity formed by this fissuring is

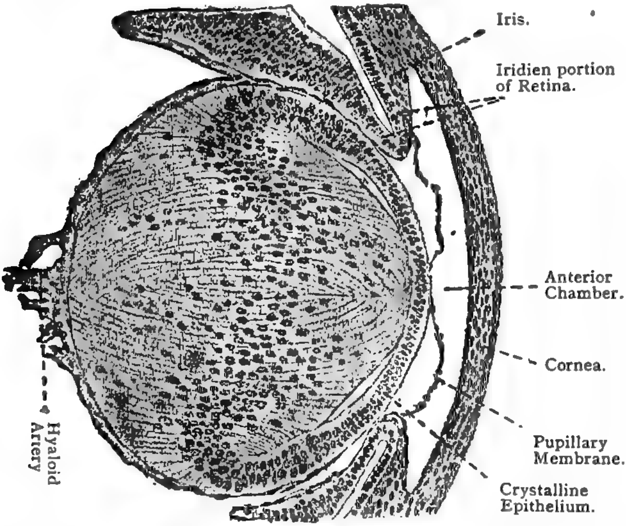


Fig. 15.—Vascular network around the lens and pupillary membrane. Embryo of mouse. (After O. Schultze. *Encycl. francaise d'ophtalm.*).

the anterior chamber, which does not yet exist. As the choroid is vascular, so the pupillary membrane is very rich in vessels which anastomose with those of the capsular membrane of the lens. (Fig. 15).

The pupillary membrane is also a fœtal organ disappearing before birth, but some traces of it are left at the insertion on the anterior surface of the iris, and in the neighbourhood of the the edge of the pupil it is possible to recognise their congenital origin, and also to distinguish iritic adhesions—patho-

logical in origin—which are seen exactly at the edge of the pupil.

The ciliary body and iris are developed at the expense of a budding of the anterior part of the choroid.

Development of the Eyelids. The cornea of the embryo remains uncovered during the first stages of development. The eyelids arise at the periphery of the orbit in the form of two circular swellings which advance to meet one another although remaining separated from the eye by a furrow. (Fig. 11). At their point of meeting they become joined together but only by their epithelial layers. This junction disappears at birth in man, and in some animals, but in others it persists for some time—about ten days in carnivora. It is permanent in the ophidians in which the eyelids remain—though thin and transparent.

(For further details of the development of the eye, *see* Van Duyse: Embryology of the Eye :—*Encyclopédie française d'opht almologie*, tome II., 1905, p. 143).

CHAPTER II.

THE EYE FROM AN OPTICAL POINT OF VIEW.

Considered as a physical apparatus the eye resembles a black chamber like a photographic camera, made up of a refracting or dioptric apparatus (composed mainly of the curved surfaces of the cornea and lens) and a screen—the retina. In one particular position of the photographic apparatus the lens, acting as an objective, gives on the screen a clear image of a plane in space which is always the same. But it can also be made to form on the screen an image of any plane in space by varying the distance of the lens from the retina, or by altering the refracting power of the lens—focussing. The same thing happens in the eye. The formation of images in the eye can be studied without allowing for accommodation (static refraction), and also for the formation of images of different points in space which are focussed by means of the mechanism known as accommodation (dynamic refraction).

The following notes on some of the elementary principles of optics are useful for the comprehension of the path of the luminous rays.

Refraction by Diopters.

When a ray of light meets a surface dividing two media of different constitution, *e.g.* air and water, or glass and water, this ray changes its direction, *i.e.* undergoes refraction. (Fig. 16.)

Between the initial direction of the ray and its direction after being refracted, there exists a relation expressed by the general formula :

$$\frac{\sin i}{\sin r} = \frac{n}{n'}$$

in which n and n' are the indices of refraction of the two media under consideration.

Supposing the first medium to be air, the refractive index of which is taken as unity, the formula becomes :—

$$\frac{\sin i}{\sin r} = n$$

If i and r are known n can be found. Or r can be found if the other two terms of the equation are known, r being the amount of refraction undergone by the ray. The indices of refraction of solids and liquids are determined in comparison with that of air. They are thus relative indices. These facts translated into ordinary language simply mean that :—Every luminous ray which passes from a less refractive medium into a more refractive one is refracted in the direction of the normal and *vice versa,* any ray passing from a more refractive medium to a less refractive is deviated from the normal.

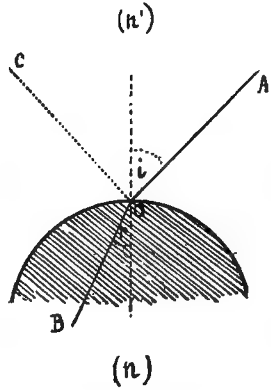


Fig. 16.

Note.—Generally when light meets a surface of separation of two media of different refractive powers it is not totally refracted, one part OC is reflected according to the laws of reflection (fig. 16).

Simple diopter. This name is applied to every curved surface separating two media of unequal refractive power.

Path of luminous rays. Suppose a diopter KK′ (fig. 17), with centre O separating two media of unequal refractive powers, n and n' respectively, n' being air and n being a medium of greater refracting power. A luminous ray PK will be refracted in the medium n towards the normal along KP′. *Vice versa* if a ray P′K is considered it will be refracted in the

medium n' in the direction KP away from the normal. The points P and P′ are for this reason called the conjugate foci. Every luminous ray starting from P will be refracted to reunite in P′, the focus of P. Every luminous ray starting from P′ will be refracted to reunite in P, the focus of P′. The further P is from the diopter, the nearer P′ approaches. A time comes when P being situated at infinity, the rays leaving it are parallel.

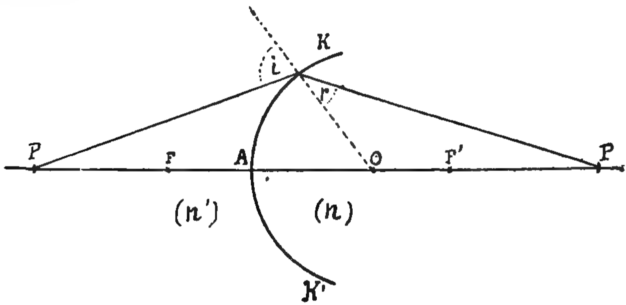


Fig. 17.

Then their focus F′ is known as the principal posterior focus.

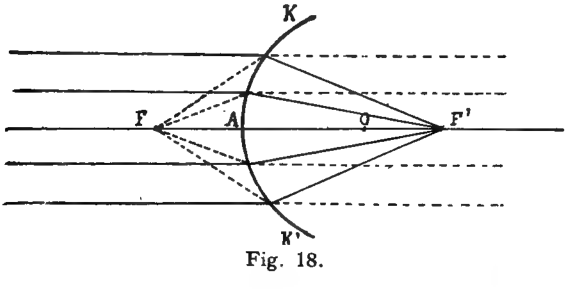


Fig. 18.

The nearer P approaches to the diopter the more distant from it does P′ become. A time comes when the situation of P is such that the refracted rays are parallel, *i.e.* P′ is at a point known as the principal anterior focus F. Every diopter has thus two foci, the distances (or focal lengths) of which points from the apex of the diopter (A) are determined as follows:

Between the conjugate foci P and P′ (fig. 17), the following relation is established:

$$\frac{1}{p} + n\frac{1}{p'} = (n-1)\frac{1}{r} \qquad \text{(i)}$$

in which p and p' are the distances of the points P and P′ from (A) the apex of the diopter, and n is the refractive index of the medium: r being the radius of the diopter.

$$\text{When } p = \infty, p' = \frac{n}{n-1} r = f', = \text{posterior focal length.} \qquad (1)$$

$$\text{When } p' = \infty, p = \frac{1}{n-1} r = f' = \text{anterial focal length.} \qquad (2)$$

The focal lengths of a diopter are thus seen to be unequal; the posterior is the greater.

Combining these formulæ the following results are obtained (these are made use of later):

$$\frac{f'}{f} = \frac{n}{1} \qquad (3)$$

i.e., the focal lengths of a diopter are directly proportional to the refractive indices of the media:

$$f' - f = r \qquad (4)$$

The radius of a diopter is equal to the difference between its focal lengths.

By replacing r in terms of f and f' in (1) the following formula is obtained:

$$\frac{f}{p} + \frac{f'}{p'} = 1 \qquad \text{(ii)}$$

Lastly representing by q the distance of the object P from the anterior focus F and by q' that of the image P′ from F′, the relation is thus simplified.

$$qq' = ff' \qquad \text{(iii)}$$

Optic Centre. Any ray such as PO passing through the centre of curvature of the diopter undergoes no refraction at this point which is called O, the optic centre.

Lenses. Lenses are made up of two diopters. The refraction of light in this case is more complicated than in a simple diopter. To find the image of a luminous point P, the conjugate point P1 of P must first be found through the first diopter, and then P2 the conjugate focus of P1 through the second diopter. This conjugate focus P2 will be the image of the point required. To avoid the difficulties of this method special points, called principal points and nodal points, have been determined, and these, with the focal points already described, form the 6 cardinal points, taken in pairs. These points possess properties which allow the paths of rays to be followed through two or more lenses—for every dioptric system can be explained if the cardinal points are known. For the study of these points the reader is referred to works on physics. It may be mentioned that the nodal points play the same part as the optic centre in a simple diopter, *i.e.* every ray of light passing through the anterior nodal point leaves the diopter in a straight line, passing through the posterior nodal point—it has undergone no refraction.

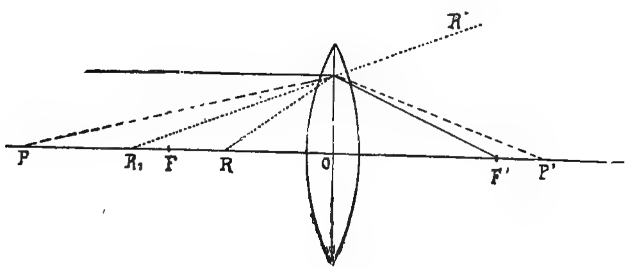


Fig. 19.

Convex Lenses refract incident rays and make them converge (hence they are called convergent lenses). If the luminous object is a point, the refracted rays reunite in another point placed beyond the lense called the principal focus. If the luminous object is of some size the refracted

rays reunite to form a smaller inverted image, which is said to be *real* because it is formed by the actual union of the refracted rays. If the rays come from a point P placed beyond the principal focus, they are refracted, and by their convergence reunite in P′, which is called the conjugate focus of P, situated at a finite distance from the focus F. Lastly, if they come from a point R situated between the focus and the lense and diverge in the direction R′, their prolongation forms at R′ the virtual conjugate focus of R.

Concave Lenses. These refract parallel incident rays and make them diverge from the normal, hence they are called divergent lenses. (Fig. 20). These divergent rays cannot

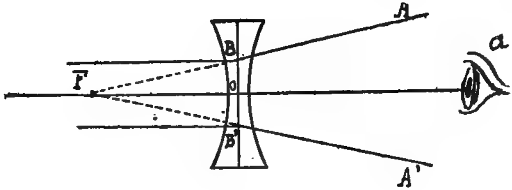


Fig. 20.

meet effectively and have no real focus, but an observer placed at "a" for example, can see divergent rays as if they come from a point F, which is the principal focus of the lense. The focus is *virtual*, for it does not exist in reality, although the observer imagines that he can see the image of the object which gives off luminous rays.

So also the rays AB and A′B′ falling on a concave lense and converging in F are refracted by the lense parallel to one another. The distance separating the principal focus F of a lense of optic centre O from the lense is called the principal focal distance. It is positive in convex lenses, and they are represented by the sign +. It is negative for concave lense, and they are represented by the sign —.

The refractive power of a lense, or in other words, its power of refracting incident rays, is directly proportional to the

curvature of its surfaces, or inversely proportioned to the focal length of the lense. These proportions can be made use of to measure the refractive power of a lense. Thus, *aliis æqualis*, a convex lense is more powerful the thicker it is at its centre.

However, the principal focal length is taken as the measure of the power of a lense, and it is convenient to take as a unit a Dioptry, *i.e.*, the refractive power of a lense whose focal length is one metre.

Being given the inverse proportion which has been shown to exist between the refractive power of a lense and its focal length, it is quite simple to calculate in dioptries the refractive power of a lense, the focal length of which is known, or to find the focal length if the refractive power in dioptries be given.

Thus, a concave or convex lense of focal length 50 cm., *i.e.*, having a focal length half that of a dioptry, has a refractive index twice as great = 2 D.

This result is immediately obtained by dividing the focal distance of the diopter, the unit of measurement, by the focal distance of the lense to be considered.

Examples :—Power of lense of 50 cm. focal length :

$$\frac{\text{Focal length of diopter}}{\text{Focal length of lense}} = \frac{1\text{ m.}}{0\text{ m}\cdot 50\text{ cm},} = \frac{100\text{ cm.}}{50\text{ cm.}} = 2\text{ D}$$

Power of lense of 25 cm. focal length :—

$$\frac{100}{25} = 4\text{ D}$$

Dioptric value of a lense of 2 m. focal length :—

$$\frac{100}{200} = \tfrac{1}{2}\text{ D or } 0\text{m. } 50\text{ D}$$

So also a lense power 4 D has a focal length $\frac{1}{4}$ that of a unit lense :—

$$\frac{100}{4} = 25\text{ cm.}$$

A lense of refractive power $= 3D$, has a length of $\frac{100}{3} = 33$ cm.

" " " $= \cdot75D$, " " $\frac{100}{\cdot75} = 133$ cm.

Constant Dioptrics of the Eye.

Before stimulating the retina, the rays of light pass through four media of unequal refractive power—the cornea, aqueous humour, lens, and vitreous humour. In consequence of its thinness the cornea can be regarded as a single layer separating the air (refractive index = 1) from the aqueous humour (refractive index = 1.33). A ray of light falling on the cornea and thus passing from a less refractive medium to one more refractive is bent towards the normal, and so more towards the principal axis.

This refracted ray at last reaches the anterior convex face of the lens capsule separating the aqueous humour ($u = 1.33$) from the substance of lens ($u = 1.48$), and is consequently refracted and converges again, and owing to the peculiar formation of the lens still further refraction takes place as the ray passes through its substance. Lastly, the ray reaches the posterior concave surface of the posterior lens capsule to pass into the vitreous humour ($u = 1.33$), where it is refracted a third time, which causes it to converge still more towards the principal axis from the normal. The media of the eye and the surfaces which separate them are so disposed that rays entering the eye are rendered more and more convergent,

Each curved surface separating two media of unequal refractive power is called a diopter, as has already been mentioned. The eye therefore possesses three diopters, the corneal, and anterior and posterior lenticular. To exactly determine the course of rays of light successively in each of three media, the radii of curvature of, and the distances separating the diopters must be known. From these data can be calculated the position of the cardinal points of the dioptric system of the eye.

These points are known as the *Dioptric Constants*, and serve to construct what is known as the schematic eye. These points have long ago been fixed in man by Listing.

In animals they have been the subject of recent comparative research by Matthiessen (man, herbivora, carnivora, birds and fishes being studied), also in the horse by Berlin, and in the ox by Mœnnich.

It may be interesting to quote some of the results here.

1 *Radii of Curvature of the Lens and Cornea.*—These are already known (See pp. 5 and 6).

2 *The Indices of Refraction of the Media of the Eye.*—The indices of the different media are practically the same in all species as regards the cornea ($u=1.337$), the aqueous humour ($u=1.337$), and the vitreous humour ($u=1.335$). But they differ for the lens: 1.49 in the horse and the dog, and 1.43 in man.

3 *Focal Lengths of the Cornea and Lens.*—The focal lengths of a diopter being proportional to the refractive indices of the media, it is easy to see that those of the cornea are unequal, as this membrane separates the air from the aqueous humour, whilst those of the lens are equal, the aqueous and vitreous humours having the same index.

Animal.	Focal length of cornea. (Matthiessen).		Focal length of lens. (Matthiessen).
	Anterior F.	Posterior F′	Fl.
	mm.	mm.	mm.
Man ...	—23·4	31·2	49·2
Horse ...	—59·0	78·8	64·4
Dog ...	—25·3	33·8	22·9

It may be remarked that in man the posterior focal length of the cornea is less than that of the lens, which shows that the refractive power of the cornea is greater than that of the lens, whilst in the horse and dog the reverse is the case, as can be seen from the following table:

Animal.	Refractive power $=\frac{100}{f}$ in centimetres. of the cornea ($f=$F′).	of the lens ($f=$Fl.)
Man ...	32·0 D	20·3 D
Horse ...	12·6 D	15·5 D
Dog ...	29·5 D	43·6 D

4 *Position of the Diopters and Cardinal Points of the Eye.* The following table gives for the Horse and Dog the distances of the diopters and of the cardinal points from the summit of the cornea (fig. 21).

	Horse. (Matthiessen)	Horse. (Berlin)	Dog. (of av. size). (Matthiessen)
	mm.	mm.	mm.
Thickness of cornea	—	1·50	—
Distance of antr. face from lens ...	5·50	8·50	4·50
,, ,, postr. ,, ,, ,, ...	18.50	21·75	12·25
,, from the retina	44·75	43·50	21·25
Position of 1st principal point (H1)	5·39	8·13	4·41
,, ,, 2nd ,, ,, (H2)	6·59	9·28	4·60
,, ,, 1st nodal point (K1)	15·68	17·03	8·44
,, ,, 2nd ,, ,, (K2)	16·89	18·18	8·63
Distance between principal and nodal points (H1, H2 = K1, K2)	1·20	1·15	·19
Distance from principal antr. focus (S1 F)	—23·56	—18·38	—7·60
Distance from principal postr. focus (S1. S′)	45·75	44·69	20·65

The anterior focal length is measured from the first principal point, H, the posterior from the second principal point, H2, and from this :

The anterior focal length (H1 F)	—28·95	—26·51	—12·01
,, posterior ,, ,, (H2 F′)	39·16	35·41	16·05

From this it follows that the posterior focus of the ocular diopter of the horse is situated a little behind the retina, which means that the eye in this animal is slighly hypermetropic (*see* p. 33), ·83 D according to Matthiessen, and about 1 D according to Berlin. The eye of the dog is also hypermetropic—3 D according to Matthiessen.

The same author comparing the distances which separate the diopters and the cardinal points in different vertebrates has worked out their relative lengths: those of man, the horse, ox, dog and cat are given below.

S1, S2, S3, are the cornea, the anterior and the posterior lenticular diopters of the eye. R is the retina, H and K are the mid-points between the principal and the nodal points, and M is the mid-point of the antero-posterior diameter of

the lens, these distances being given in terms of S1 M (fig. 21), or they may be expressed in terms of S1 R determined, or easy to determine. From these data the schematic eye can be constructed for different species.

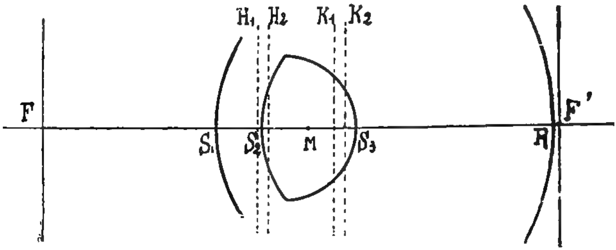


Fig. 21. Schematic Eye of Horse.

Animal.		S1S2.	S1H.	S1M.	S1K.	S1S3.	S1R.
Man	...	0·69	0·37	1	1·37	1·38	4·48
Horse	...	0·56	0·59	1	1·43	1·70	3·84
Ox	...	0·51	0·63	1	1·30	1·69	3.40
Dog	...	0·55	0·55	1	1·03	1·48	2·58
Cat	...	0·48	0·49	1	1·07	1·53	2·52

Size of images on the retina. An examination of fig. 22 shows that the images on the retina *r* and *r'* of the same object AB for two different eyes are proportional to KR and

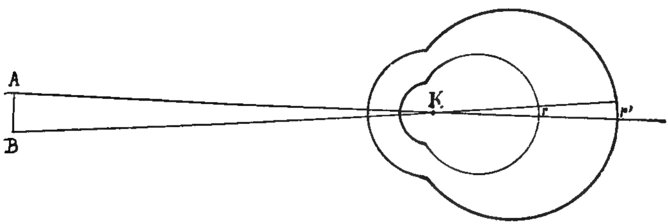


Fig. 22.

KR', *i.e.*, to the distance separating the optic centre K from the retina. Now this distance is itself proportionate to the length of the antero-posterior diameter of the eye; hence it follows the size of the image on the retina increases with the length of the eye.

Thus the horse has an image on the retina about twice as long and four times as great in area as a man has. This does

not mean to say that the horse sees objects twice the size a man sees them, for the images r and r′ for example, are subtended by the same visual angle in space. But the images on the retina are perceived—other things being equal as regards the sensitiveness of the retina—more clearly, this condition of clearness also being proportional to their increase in size. These facts hold good for the horse.

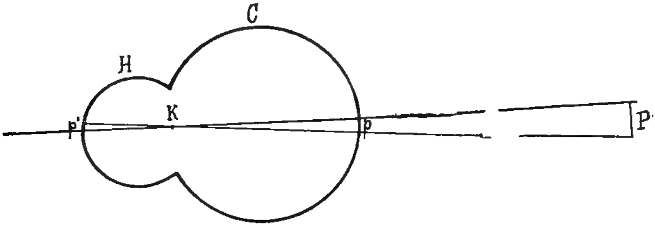


Fig. 23.

Increase in Size of the Erect Image of the Fundus Oculi.

In fig. 23, C, the eye of a horse, and H, the eye of a man examining it, are supposed to be coincident at their optic centre K. The portion of the retina p (for example the papilla) of the horse will give on the retina of the observer an image p′, and this will be seen projected in space, at the distance of distinct vision, of a size equal to P. (Fig. 23).

Now the increase required has this proportion $\frac{P}{p} = \frac{KP}{Kp}$

If p is taken as being equal to unity, $P = \frac{KP}{Kp'}$

Berlin takes KP, the distance of distinct vision as being equal to 30 cm.; Kp being in the eye of the horse about 25 mm., the upright image of the optic papilla would thus be increased by about 12 times. This figure is obviously too high, the empirical increase in size not appearing to be more than seven or eight times. Taking 22 cm. as the distance of distinct vision instead of 30 cm. the increase appears to be about nine times—the correct figure.

The Reduced Eye. By this is meant a simplification of the schematic eye consisting in the reduction of the three diopters to a single one having for centre the point K—the mid-point between the nodal points, and for radius the distance between this point and H, the mid-point between the principal points. K thus become the optic centre, and the point H is the summit of the diopter which separates the air (index $= 1.33$ or $\frac{4}{3}$). As in all simple diopters, the focal lengths are measured from the summit of the diopter. The reduced eye in man most used is that of Donders with radius 5 mm. The formulæ of the principal foci in terms of r and n (*see* p. 21) give the posterior focal length $f' = 20$ mm, and the anterior focal length $f = -15$ mm.

For the reduced eye of the horse Berlin gives $r = HK = 8.90$ mm, or in round figures 9 mm, which makes $f' = 36$ mm, and $f = -27$ mm. But Matthiessen has simplified this and proposes a diopter of radius 10 mm, this makes:

$$f' = 40\text{mm.} \qquad f = -30\text{mm.}$$

The reduced eye of the ox (Mœnnich) is a curved surface of 7 mm. radius, and the foci of which are consequently 28 mm. behind and 21 mm. in front of the summit of the diopter.

The schematic eye of the dog measured by Matthiessen can be replaced by the reduced eye of radius 4 mm., which makes its posterior focal length $f' = 16$ mm. and anterior $f = -12$ mm.

Refractive power of the ocular diopter. Being inversely proportional to the posterior focal length, the refractive power of the eye is

$$\frac{100}{4}\text{ cm.} = 25\text{ D in the horse,}$$

$$\frac{100}{2.8}\text{ cm.} = 36\text{ D in the ox,}$$

$$\frac{100}{2}\text{ cm.} = 50\text{ D in man,}$$

$$\frac{100}{1.6}\text{ cm.} = 60\text{ D in the dog.}$$

Ocular Refraction.

Static Refraction.

A. When an eye can be compared to a diopter constituted by a surface of revolution round an axis, whose posterior focus coincides with the retina, the eye is said to be emmetropic (correct measure).

B. Every eye not agreeing with these two conditions is said to be ametropic (incorrect measure).

Ametropia may therefore arise from two causes, which may be either separate or combined.

(a) The diopter is a surface of revolution, but the principal focus does not coincide with retina—the eye is then said to be myopic or hypermetropic.

(b) The diopter is not a surface of revolution—the eye is astigmatic (a = without, stigma = a point). Each of these conditions must be studied.

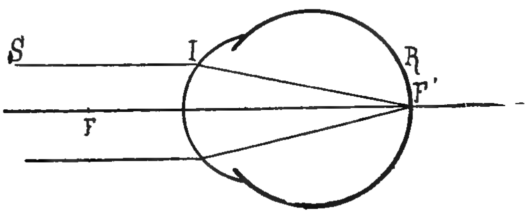


Fig. 24.—Emmetropia.

Emmetropia. *In an emmetropic eye (which will in the future be spoken of as "an eye E") the diopter is a surface of revolution whose anterior focus coincides with the retina. This is a normal eye.* (Fig 24).

In such an eye parallel rays coming from infinity unite on the retina to form a clear image. Conversely the retina, if illuminated, sends out rays which leaves the eye parallel to one another and form their image at infinity in a point called the *conjugate focus of the retina* or the "*punctum remotum*," or more simply the "*remotum.*"

Thus the eye E only sees clearly objects at infinity which send it parallel rays. *In practice, objects situated at five metres from the eye are considered as sending parallel rays.*

Myopia. *In a myopic eye M the diopter is a surface of revolution, but its posterior focus is situated in front of the retina.* (Fig. 25). Parallel rays coming from infinity reunite in front of the retina at F′, the principal focus of the diopter, and consequently] form "circles of diffusion" (s s′) on the retina.

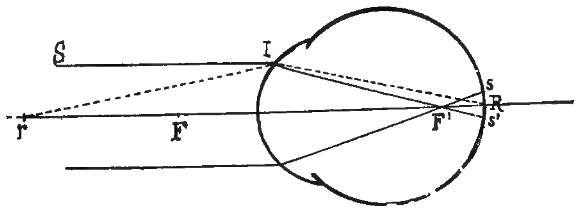


Fig 25.—Myopia.

In other words the eye M has no clear image of objects situated at infinity. Only rays starting from *r* form an image on the retina. Conversely the retina, if illuminated, gives out rays which leave in convergence to reunite in *r* the *conjugate focus* of the retina or its *remotum*. The eye M therefore only sees clearly objects placed at a finite distance in front of it, *i.e.* objects which emit convergent rays such as *r*.

This error of refraction may arise from several causes:

(a) Lengthening of the antero-posterior axis of the eye, which may be due, as in man, to congenital conformation, or to a lesion of the posterior pole of the eye (sclero-choroiditis) which, by lessening resistance, allows intra-ocular pressure to push back the retina. This is *axial myopia.*

(b) Increase in the curvature of the diopter—*curvature myopia.*

(c) Increase in the index of refraction, or *myopia of the index.*

The last two causes both result in diminishing the posterior focal distance, *i.e.* in increasing the refractive power of the eye. In any case *the eye M can be considered as possessing an*

excessive power of refraction. In fact if a lense of 1 D convexity be placed before an emmetropic eye its refractive power is increased, and parallel rays leaving the eye go (after refraction) to form their image at a point 1 metre in front of the lens. The eye E has thus been rendered myopic of 1 D. Conversely an eye M, the conjugate focus of whose retina or the remotum of which is situated at a distance of one metre from the eye is equivalent to an eye E to which has been added a positive lense of 1 D.

It really has an excess of refractive power = 1 D, and it is thus said to be myopic of 1 D. In the same way an eye M of which the conjugate focus of the retina is at 25 cm. in front of the eye is equivalent to an eye E, to which has been added a lense of $\frac{100}{25} = 4$ D. Its excess of refractive power (*i.e.*, its degree of myopia) is = 4 D.

The distance of the remotum measures the degree of myopia. Again, an eye M of 1 D, *i.e.*, the conjugate focus of whose retina is 1 metre in front of the diopter, is reduced to the condition of an eye E when a negative lense of 1 D is placed before it, since the conjugate focus of the retina from which rays leaving the eye converge is found to be the principal focus of the negative lense.

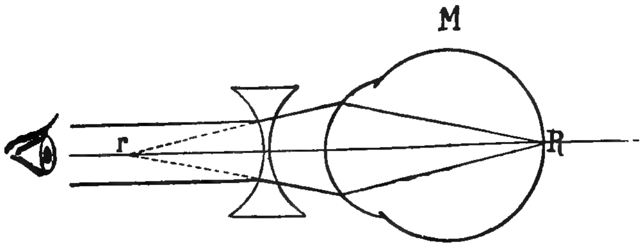


Fig. 26. Correction of Myopia.

In the same way an eye M of 3 D will become E if a negative lense of 3 D is placed before it. Briefly stated, this means that the negative lense which brings back to a state of parallelism the convergent rays emitted by the eye M is the *corrective*

lense. It measures the degree of myopia. On this principle is based the ophthalmoscopic examination of the eye by means of the erect image.

Hypermetropia. In the hypermetropic eye H the diopter is a surface of revolution whose posterior focus is situated behind the retina (fig. 27). Rays coming from infinity form their focus F′ behind the retina which, in consequence, only perceives a blurred image, due to circles of diffusion (s s′). Rays coming from a finite distance form their focus still further behind the retina, and consequently only allow it a still more blurred image. It is only convergent rays falling on the eye H (such as K I), which can form their image on their retina and give a clear image. Now these convergent rays do not exist in nature—rays emitted by a luminous body being either parallel when they come from infinity, or divergent when they come from a finite distance.

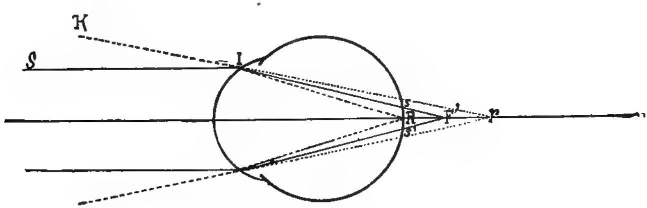


Fig. 27.—Hypermetropia.

They can only be rendered parallel by artificial means, *i.e.* without the aid of glasses the eye H can neither see distant objects as the eye E does, nor near objects as the eye M does.

The illuminated retina of an eye H emits rays which leave the eye in divergence, and which cannot meet. They have no real image. But, as has already been shown, their point of prolongation forms a *virtual* focus placed behind the eye at a finite distance from it—this point is the conjugate focus of the retina or its *remotum.* This error in refraction may be due to several causes, the reverse of those causing myopia—it may be due to a flattening of the eye in front or behind, or to a defect of refractive power of the dioptric media from

defects of curvature or index. But from an optical point of view the eye H can always be considered as having a deficiency of refraction: otherwise stated, it is in the condition of an eye E, the refractive power of which has been diminished by adding concave glasses.

So if before an eye E a concave glass of 1 D is placed, parallel rays leaving the eye will be rendered divergent on leaving the lense, and will form a virtual focus one metre behind this lense.

The eye H, having its focus 1 metre behind the diopter, has thus a deficit of refractive power = 1 D. In the same way an eye H having its focus ·25 cm. behind the diopter has a refractive deficiency of $\frac{100}{25} = 4$ D. As in the eye M, *the distance of the remotum also measures the degree of Hypermetropia.*

Again, if before an eye H of 1 D is placed a positive lense of 1 D, this eye will be brought back to the condition of eye E since the degree of refractive power which it lacks has been added to it (fig. 28).

The lense which brings back the rays leaving the eye H to a condition of parallelism is called, as before, *the corrective lense—its power in dioptries gives the degree of hypermetropia* (fig. 28).

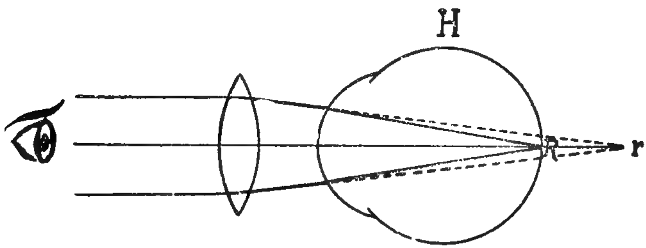


Fig. 28. Correction of Hypermetropia.

Equivalence of the dioptry in axial length. Measurement of inequalities of the fundus oculi. It has been mentioned that, according to Matthiessen and Berlin the eye of the horse has its principal posterior focus about 1 to 1·5 mm. behind the retina. The eye is therefore hypermetropic. To what degree?

Taking the case in which the posterior focus is situated 1 mm. behind the retina, other deductions can be made. Knowing the position of the retina, where is its conjugate focus?

Now, between the conjugate foci we have the simplified relation (fig. 21):

$$qq' = ff'$$

in which we know q' to be 1 metre, and the focal distances f and f' to be 30 and 40 mm. respectively (reduced eye of Matthiessen).

The required position of the conjugate focus is determined thus: $q = 30 \times \frac{40}{1} = 1200$ mm. $= 1$ m. 20 cm.

The conjugate focus of the retina being therefore situated 1 m. 20 cm. behind the eye diopter,* and this distance measuring the degree of hypermetropia, this is therefore (H) $= \frac{1}{1{\cdot}20} = {\cdot}83$ D. This is the degree of hypermetropia of the eye looked at. It may now be deduced that .83 D (centimetres) of Hypermetropia is equivalent in the horse to 1 mm. of length of axis, and that 1 D = 1.2 mm. The same reasoning is applicable to Myopia. Thus, when the erect image has been determined, at the same time has been determined how far a tumour at the depth of the eye has pushed forwards the vitreous humour or a detached fold of the retina, or also to what extent the papilla has been forced back, *e.g.*, in glaucoma or hydrophthalmos. Analogous reasoning shows that for the eye of man D = ·3 mm. length of axis; for the dog D = ·2 mm.; and in the ox D = ·6 mm.

Calculation of the degree of H in Aphakia. In an eye which has been the subject of an operation for cataract, or in which the lens is luxated (to both of which conditions the term Aphakia is applied, as the lens is not playing it proper part), what is the new refractive power of the eye? An eye, the

* In reality the conjugate focus is situated at 1 m. 20 cm., less the anterior focal length (which may be 3 cm.) since q is measured from F. This error is not taken into account either in Myopia or in Hypermetropia.

subject of Aphakia, is reduced to the condition of a simple diopter, formed by the cornea, separating the air from the aqueous and vitreous humours, these last two media having the same refractive index = 1.33. Now, all the parts of the corneal diopter are known, and the problem resolves itself into finding the conjugate focus of the retina with regard to this diopter.

The formula of the conjugate foci is $\frac{F}{p} + \frac{F'}{p'} = 1$, in which F and F' are the focal lengths of the cornea, and p' the distance of the retina from the cornea (this may be taken as 44·75 mm. in the horse), and p the required focal length of the retina.

$$p = \frac{Fp'}{p' - F'} = \frac{59 \times 44{\cdot}75}{44{\cdot}75 - 78{\cdot}8} = -\ 77 \text{ mm.}$$

The conjugate focus of the retina being virtual and situated 7·7 cm. behind the summit of the diopter, the eye (in a condition of Aphakia) of the horse has a hypermetropia $\frac{100}{7{\cdot}7} = 13$ D. (about).

The correcting glasses of the ophthalmoscope placed 5 cm. from the cornea will have 7·7 + 5 = 12·5 cm. focal length, and a refractive power $\frac{100}{12{\cdot}5}$ = 8 D., a figure which has actually been found in several cases by the method of the erect image (p. 67).

Astigmatism. When the eye diopter is no longer represented by a surface of revolution, *i.e.* has not the same curvature in all its meridians, it is said to be astigmatic. The rays do not form their images at the same point and vision is not clear.

Regular Astigmatism. The eye has meridans whose curvature varies progressively from one to another, but remains constant throughout the same meridian. The meridian of greatest and that of least curvature are called the principal meridians; they are almost always perpendicular *to one another,* but not always so that one is vertical and the other

is horizontal. *The difference in refraction between them measures the astigmatism.* As a rule the vertical meridian is the most refractive, and the horizontal the least. Exceptionally the reverse is the case. In the first case the astigmatism is said to *conform to the rule*, and in the second case to be *contrary to the rule.*

Irregular Astigmatism. Here there is no regularity in the curvature of the meridians of the diopter, either when viewed with regard to one another, or one by one. Naturally in this case sight is very bad, since refraction takes place in every direction. An idea of the condition can be obtained by looking through a piece of facetted glass or a piece of uncut rock crystal.

This anomaly of refraction is sometimes due to congenital alterations in the cornea or lens, but more often to acquired conditions. In the cornea, keratoconus, staphyloma, opacities, superficial and deep punctated keratitis; in the lens, sometimes very great differences in refractive power exist between the nucleus and superficial layers; this, and false cataracts may cause the condition.

Circles of Diffusion in Ametropia. As has already been shown, circles of diffusion result from the refracted rays not forming their focus on the retina, which cuts the luminous cone either in front of or behind the focus, as in H and in M respectively. (Fig. 29.)

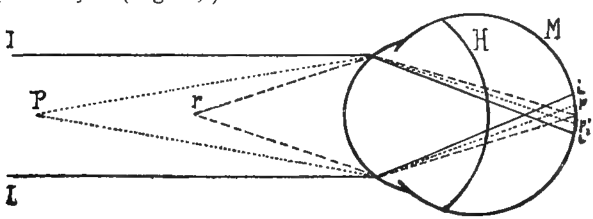


Fig 29

The image on the retina of a point in space thus becomes a circle, and it can be seen that the image of a line becomes a rectangle with rounded angles formed by the superposition

of as many circles as there are points on the line. Vision is therefore faulty, just as the image on the screen of a camera is faulty when the screen is not in focus. It is also faulty in direct proportion to the size of the circle of diffusion. Now, *aliis æqualis*, the size of the circles of diffusion varies with (*a*) the distance of the object from the eye, and (*b*) the size of the pupil. A few words must be said about each of these points to allow certain facts to be understood.

(*a*) In the case of a myopic eye, whose remotum is at *r*, which means that *r* is the far point of distinct vision (fig. 29), the luminous point P forms circles of diffusion *pp'*, whilst the point I, situated at infinity, forms circles of diffusion *ii'*.

The more distant an object is from a myopic eye, on the far side of its remotum, the greater are the circles of diffusion and consequently the worse is the vision; this is why persons suffering from myopia bring objects they are looking at close up to the eye (to the remotum) to the point at which vision is clearest, and at which circles of diffusion no longer exist.

In the eye H, as can be seen in fig. 29 (H being the screen or retina), the contrary is the case. The nearer the object to the eye the greater the circles of diffusion and the worse the vision.

(*b*). Circles of diffusion may vary with the size of the pupil :—

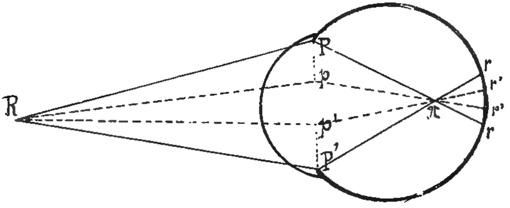


Fig. 30.

Take a luminous point R (fig. 30), and whose conjugate focus is in *n* in a myopic eye. With pupil dilated to PP' the circles of diffusion are *rr*, whilst with dilatation *pp'* they are *r'r'*. The sight of a myopic eye (*a.e.*) is therefore better with

a small than with a large dilatation of the pupil. This explains why a short-sighted person half closes the eyelids when looking at distant objects, for he thus restricts at will the size of the opening which admits the luminous rays, and also why he blinks his eyes.

Stenopæic Vision. *Vision through a hole or narrow cleft.* If a plate pierced only by a single pin-prick or by a very narrow cleft is placed before an ametropic eye (or an astigmatic eye), it renders vision clearer by diminishing the circles of diffusion.

The physiological reason for slit-like pupil in animals. Perhaps the principal of the stenopæic cleft explains the form of the pupil in some animals. This suggestion was made by Wolfskehl, who found that in the eye of the calf, in which the pupil is oblong with its major axis horizontal, the vertical meridian of the cornea is the most curved (seven times in eleven examinations), and this consequently forms circles of diffusion. This vertical narrowing of the pupil would correct the corneal astigmatism. In the same way Wolfskehl has found in the cat, in which the pupil resembles a vertical buttonhole, that the horizontal meridian of the cornea is the most curved (four times in five examinations). The rabbit, whose pupil is circular, shows no appreciable corneal astigmatism (Schelske). These facts go to prove Wolfskehl's assertion. However, Kalt remarks that Matthiessen has noticed that the direction of the pupil appears to have an important relation to the habits of the animal. "The horizontally elongated pupil met with in the Herbivora seems to agree with the peaceful and harmless existence they lead, whilst the vertically elongated pupil of beasts of prey (cat, fox, lynx, owl, crocodile, shark) which move quietly whilst spying around them, seems to harmonise with their habits of cunning and cleverness." Animals with an horizontal pupil (such as the horse and ox) have special need for a horizontally extended field of vision, for example in grazing, and the rest require a vertical field of vision, and a pupil with its major axis vertical, such as cats waiting for birds, and owls seeing mice when on the wing. Although the pike has biologically and morpho-

logically a certain relationship to the crocodile its pupil is horizontal, the field of its plunder being horizontal. The massive structure of the Cetaceans does not allow them to turn the head, and as the field of vision of the whale always extends in a horizontal direction, so on the surface of the water an elongated pupil is best suited to its needs. (Matthiessen).

Dynamic Refraction or Accommodation. The eye in a state of rest (which has been under consideration above) can only see distinctly objects situated at its remotum. Every object situated anywhere else but on the remotum cannot have a clear image on the retina if the eye did not possess the power of varying the refractive power of its dioptric apparatus, *i.e.* of focussing points. This power is called accommodation, but it must be noted that it can only be exercised on objects on the near side of the remotum. The factors making accommodation possible are the contraction of the ciliary muscle and the elasticity of the lens.

In a static eye the ciliary muscle is at rest, and the eye possesses its minimum of refractive power. In a dynamic eye, or in accommodation, the ciliary muscle is capable of contraction, and the eye increases its refractive power to a maximum. Then the eye has an image of the nearest objects which it is able to see clearly. The refraction of the eye is thus capable of being modified according to the distance of the object to be observed.

To see an object clearly the ciliary muscle must receive a stimulus calculated for the distance of the object. The nearest point at which an eye can see clearly in a state of accommodation is called its *proximum*. Dynamic vision thus exercises its power over the distance separating the remotum from the proximum. This distance is known as *the amplitude of accommodation.*

Measurement of accommodation. If, before an eye in a state of rest is placed a convex lense of = 1 D, its remotum is fixed at 1 metre. Objects situated at 1 metre from the eye will be the only ones seen clearly. But if on removing this lense the eye makes an effort to see an object at 1 metre, it will conse-

quently have accommodated itself 1 D. Thus accommodation can be expressed in dioptries, or can be represented by a convex lense added to the eye in a state of rest.

The power of accommodation is the refractive power of a convex lense which, placed before an eye at rest, produces the same same refractive effect as accommodation intervening with its maximum of energy.

The power of accommodation diminishes with age. It is at ten years of age in the human subject 14 D. At forty-five the effective amount is not more than 3 D for a continuous effort. At seventy it is *nil.* In other words the punctum proximum of a child ten years of age $= \frac{1}{14} = 7$ cm.; that of a man of forty-five is $\frac{1}{3} = 33.33$ cms., and that of an old man is at infinity and coincides with his remotum.

Reading is difficult therefore for a man of forty-five at less than 33 cm., and he is obliged to wear glasses. This phenomenon is known as presbyopia (from *presbus*, an old man). In this condition sight is good at a distance but bad for near objects without glasses.

It thus differs from hypermetropia, in which sight is good neither for short nor long distances unless excessive accommodation is used. This condition of refraction depending on old age is determined by sclerosis of the lens which hinders it from changing its shape under the influence of the contraction of the ciliary muscles. At seventy years of age the lens resemble a glass lense.

Convergence.—Every time both eyes are fixed on a point in space they converge, and this they do in proportion to the nearness of the object looked at. Convergence is thus proportional to accommodation. The two eyes looking at infinity converge at infinity. Their convergence at one metre is termed a metric angle, and if they are regarding a point 25 cm. distant they converge $\frac{1}{0.25} = 4$ metre angles. *A metric angle of convergence thus corresponds to a dioptry of accommodation.*

CHAPTER III.

METHODS OF EXAMINATION OF THE EYE.

Before commencing to study affections of the eye, it is indispensible to understand the methods by which the eye can be examined. These comprise examination by *the naked eye*, by *lateral* or *oblique illumination*, and by the *ophthalmoscope*. Special examinations such as *pupillary reaction*, *tonometry*, *Sanson's images, visual acuteness, etc.*, should be familiar.

In the following explanations the horse is referred to in every case, but everything so explained may be taken as applicable to the other animals, unless mention is made to the contrary.

Naked eye examination. This procedure is applicable to the orbit, eyelids, conjunctiva, lacrimal canals, and the anterior segment of the eyeball—cornea, aqueous humour, iris, and the anterior capsule of the lens. In examining the anterior segment of the eyeball the head of the animal should be placed looking out of a doorway, a little to the inside. To get a good light a door turned towards the south should be chosen, but direct solar rays must be avoided. [Images of outside objects are often cut off by interposing a black hat]. Small animals may be placed on a table in front of a window. This examination, under favourable conditions as to light, gives very good results as to the transparency of the cornea, the state of the aqueous humour, and the anterior chamber; also the appearance of the anterior face of the iris and the border of the pupil.

As a rule the examiner can straightway proceed with the next method if the light is good and the animal in a suitable position.

Examination by Focal, Oblique, or Lateral Illumination.—This is chiefly concerned with the anterior segment of the eyeball.

Instruments required.—An ordinary paraffin lamp, or preferably a dark lantern with a reflector, such as that used by policemen (Ablaire), and a bi-convex lense of 15-20 D are necessary—sunlight cannot be used. For this method Priestley Smith has designed an original combination worthy of mention (Fig. 31). A pocket electric lamp gives perfect results, and certainly excels all the others if the dry battery does not become exhausted when not in use.

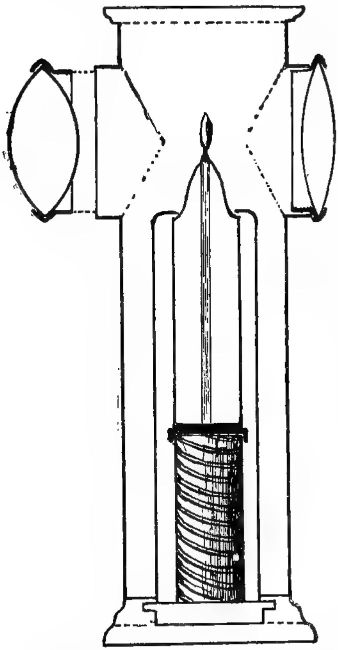


Fig. 31.—Priestley Smith's Lamp.

Preparation.—The examination of the cornea, anterior chamber, and anterior face of the iris needs no atropin. To examine the lens and to reveal the existence of posterior adhesions of the iris two or three drops of a solution of atropin (1:200), should be instilled into the eye.

Method of Procedure.—The animal is led into as dark a place as possible, but an absolutely dark room is not indispensible, a corner often sufficing. It is held by an assistant by the bridle and an ear, whilst a second assistant holds a lamp at the disposal of the observer. This lamp is placed on the same side as the eye to be examined, at the same height as the eye, and may be either in front of or behind it, in such a way that luminous rays reach the eye obliquely (fig. 32).

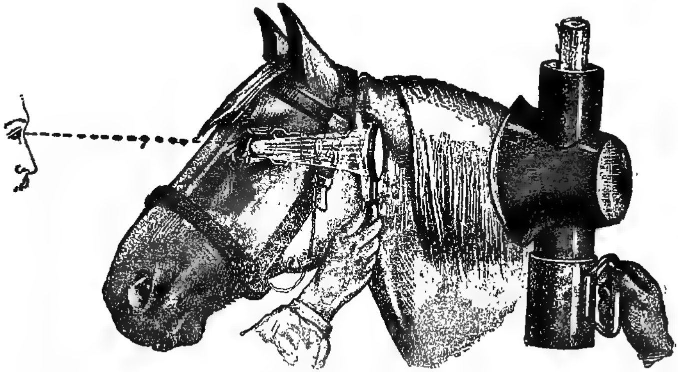


Fig. 32. *Focal, Oblique or Lateral Illumination* (Cadiot and Almy).

The rays are rendered less oblique when a deeper part is to be examined. The distance of the lamp varies with its candle power. Practice soon determines the best position.

The observer places the lense on the track of the rays coming from the lamp and concentrates them on the part to be examined. By varying the distance of the lense from the eye and the position of the lamp the maximum of illumination is obtained on the part to be examined. The details of the part are clear in proportion to the number of rays reflected from it, *i.e.*, in proportion to its opacity and power of absorption (as in the case of the anterior face of an opaque lens). Oblique illumination is used in every case in which a naked eye examination will not give sufficient information. It is especially indispensible in localising corneal opacities.

Purkinje-Sanson's Images.—A source of light—lamp, candle, or match—placed before the eye in a dark room gives three images on the field of the pupil formed on the three curved surfaces of the cornea and lens capsules. Two are erect, but differ in size and brightness, and *these move in the same direction as the light* when it is moved. These are furnished by the convex surfaces of the cornea (when the image is very small and bright), and the anterior capsule of the lens giving a large blurred image. The third inverted, small and *moving in an opposite direction to the light*, is fairly bright in

the horse and dog, and is furnished by the posterior capsule of the lens.

These three *chief images* are called Purkinje-Sanson's images and are used by physiologists to determine the changes in curvature of the lens in accommodation, and also by clinicians in ordinary ophthalmic semiology. [By them it is called the *catoptric test*]. They are only quite clear if the corneal and capsular surfaces are quite transparent.

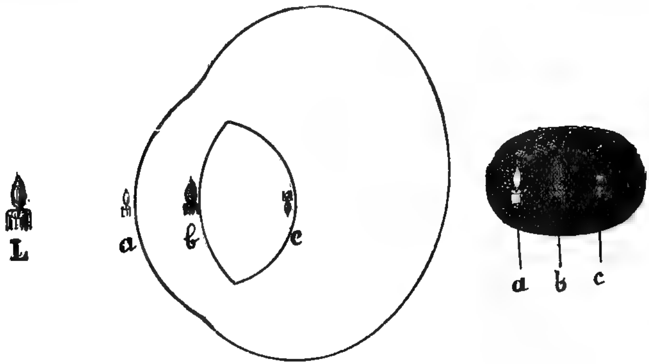


Fig. 33.—Images of Purkinje-Sanson.

When opacities exist they form reflecting surfaces, and in the light from these the images are more or less blurred.

Certain opacities of the lens capsule, especially the posterior, hardly visible with an ophthalmoscope, are thus shown up. On the other hand the absence of the third and second images is seen in aphakia and luxation of the lens. In the second of these cases the second image may persist if the anterior capsule of the lens has remained in place. In other cases *supplementary* images may be seen—these may be physiological. Tscherning has studied four which result from multiple reflections in man; they are as a rule only faintly visible. There are also some abnormal images visible with the naked eye, which, as a rule, result from lack of homogeneity (concentric circles), or opacity of the lens; in about 15 horses Bayer and Schmidt have found four and five images.

Examination by means of the Ophthalmoscope.—In the same way that, as in daylight, a dark interior lighted only by a small opening is not visible to a person outside, so the interior of the ocular globe is not visible to the naked eye without artificial means because it is not sufficiently lighted—the pupil being too small—and also because the pigment of the retina, which covers the posterior wall, absorbs too many of the luminous rays, and for still other reasons which will be mentioned. The eyes of large animals, however, are provided with a "tapetum," a deeply situated reflecting surface, and their pupil being large this explains why in certain cases, and under certain conditions, the depth of the eye in the horse, ox, dog, and cat are visible without artificial means—everyone has seen the eye of a cat shining in a dark room. If a horse in a badly lighted stall turns his head to the door it often happens that the pupil assumes the green shade of the tapetum lucidum or the red shade of the papilla, according to whether the incident rays strike one or other of these reflecting surfaces.

But if the horse is placed in a doorway it immediately becomes impossible to see the depth of the eye, because a great number of incident rays are reflected by the cornea and the faces of the lens capsules and strike the eye of the observer more forcibly than the rays thrown out by the depth of the eye observed. A phenomenon is thus produced similar to what happens when a man is standing outside a brilliantly lighted window—the reflection of the rays on the glass of the window blurr his vision and prevent him from seeing the inside of the room.

That rays are reflected by the lens is proved by the fact that in aphakia the depth of the eye can be seen without an ophthalmoscope. Every detail can be seen—the ocellated points of the tapetum lucidum as well as the papillary vessels—less clearly, however, than with an ophthalmoscope, which latter fact proves the reflecting power of the cornea. Place a horse with a luxation of the lens inside a dark stable, his head turned towards the light and so placed that the exam-

iner's eye will be struck by rays coming from the eye—the fundus oculi can be seen very clearly.

Direct illumination of the eye by means of an ordinary source of light, such as a lamp or candle placed before the eye, cannot give the desired result, since the examiner's eye receives numerous rays direct from the source of light, whose intensity is greater than that of those coming from the fundus oculi, which he wishes to see; the latter rays being drowned in the former give no clear image. The case is similar to that of a man walking in a dark cellar with a candle placed directly before his eye, a few centimetres from it; he can see much better if he holds the candle at arm's length, and still better if he screens his eyes from the direct light of the candle with his hand.

In 1848 Brücke, having noticed this phenomenon happened to see the interior of the eye in making the following experiment. He placed a candle before the eye he wished to examine, put a screen behind the candle, and looking from behind the screen he was able to see the fundus oculi for the first time. The orthoscope (to be described later) is based on this principle.

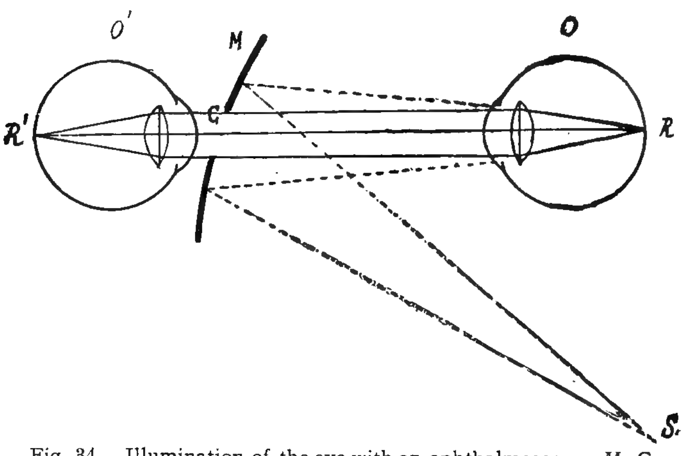


Fig. 34.—Illumination of the eye with an ophthalmoscope. *M*. Concave mirror. *S*. Source of light. *O'*. The observer's eye. O. The eye looked at,

It is therefore necessary in order to see the depth of the eye (*a*) that it is sufficiently illuminated, (*b*) that the eye of the observer is shaded from the rays coming from the source of light, (*c*) that the observing eye be placed in the path of the rays coming from the eye to be examined.

*Helmholtz' discovery.**—This observer realised the above conditions in 1851 when he reflected into the eye luminous rays from a source of light placed laterally by means of a sheet of glass inclined at 45°. Under these conditions the depth of the eye illuminated became the luminous object sending out a beam which, on leaving the eye, was partly reflected on to the sheet of glass, while the other part of the luminous beam going through the glass went to the eye of the observer placed behind. This is the principle of the ophthalmoscope, which has only been improved in details.

Thus the reflecting plate of glass of Helmholtz has been replaced by a plane, or more often by a concave mirror pierced in the middle by a small circular hole, allowing the observer to receive only the rays coming from the illuminated eye. (Fig. 34).

Ophthalmoscopic practice involves several conditions which we shall study one after another: the examination of the media; the examination of the deep membranes; the determination of refraction.

Examination of the Media: Also called examination by direct illumination. *Choice of a Source of Light.* In man, in whom the pupil is small, and the deep membranes are everywhere lined by a thick layer of absorbent pigment, it is necessary to use a powerful source of artificial light, such as an oil lamp or a gas burner. In veterinary practice the same procedure may be adopted, but illumination of the pupil is more difficult because of the constant movements of the

* The ophthalmoscope was first invented by Chas. Babbage about 1847, but as an eminent ophthalmic surgeon to whom he showed it did not appreciate its utility, it was cast aside until Professor Ruete re-invented it 1852, This instrument was practically the same, with a few slight alterations, as that now in general use.—*Trans. and Edit.*].

animal's head, necessitating corresponding movements of the source of light. The belief that artificial light was indispensable to the application of the discovery of Helmholtz, was certainly one of the reasons why at first ophthalmoscopy made little progress in veterinary practice, despite the attempts of Reynal, who, in 1865, seems to have been the first to put the new discovery into practice.

Illumination by daylight. Fortunately one observer, whose name is not known, thought of using *diffuse daylight*, which made ophthalmoscopic examination in animals unique in its simplicity. On account of the size of the pupil in animals, and still more on account of the presence of a reflecting surface at the depth of the eye—the tapetum lucidum, which is not found in man—daylight is the best source of illumination. It presents the great advantage of being always at the disposition of the observer and of always falling on the mirror of the instrument whatever the position of the observer may be, of not necessitating a dark room, and of not changing the colour of the parts on which it falls. With daylight, illumination of the eye is merely reduced to throwing a pencil of rays into the eye by means of a mirror, a simple procedure which anyone can perform with success and without much practice. Direct solar rays must not be used as they dazzle the animal and cause it to resist. As far as possible rays reflected from any external object should be avoided, at least it should not be a white wall (Ablaire), which gives to the fundus oculi a yellowish shade which may be mistaken for a pathological change: in fact, light should not be affected by contact with any obstacle. *Diffuse rays* from the sky should be used; whether it be clear or cloudy does not matter. With a little practice it is easy to make an ophthalmoscopic examination with light taken from either of the four cardinal points—the examiner placing himself under a shed, in a doorway, in the light of a window, or in a closed stable. But for a beginner certain conditions are necessary which we will now mention.

Locality. Choose a stable doorway facing South (or East in the morning and West in the evening), in order to have a good

light. A stalled stable lighted by a window above the door (Ecurie-dock) is particularly good, as it is easy to close the door, and so make it darker and to receive the rays of light in a favourable direction.

Position of the animal. It should be placed parallel to the door with the eye to be examined turned towards the interior of the stable. An assistant placed on the opposite side holds the bridle with one hand and the ear with the other. In this position the eye to be examined is placed in the shadow thrown by the head, and this relative obscurity is sufficient to see the image clearly. The dog and cat are placed in the same way before a window, and the observer, being seated, examines at his ease.

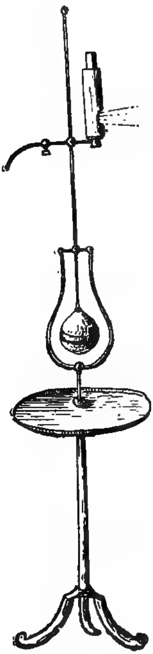


Fig. 35.

Artificial Illumination. Preference should be given to the use of daylight, which gives the best results with most observers and should lead to a general use of the ophthalmoscope in veterinary work, but some observers, of great experience, prefer the use of an artificial light. Professor Vachetta, of the Veterinary School at Pisa, has for a long time used in his teaching (besides daylight) a gas bracket of ingenious design invented by himself (fig. 35). At the end of a long vertical rod, movable round a horizontal axis and kept in position by a counterpoise, a gas burner is fixed, at a convenient height, by means of a thumbscrew. A metal chimney pierced by a small hole allows only a beam of light to pass out. The whole apparatus is fixed on a tripod, or preferably on a table on which the instruments needed for the examination can be placed. Less convenient and less easily moved are the various oil or petroleum lamps with convergent reflectors which can be bought in any town, and are recommended by Vachetta, Rolland, and Ablaire.

The artificial source of light is placed on the side of the head opposite to the eye to be examined and slightly in front of it, in such a way that rays fall tangentially to the forehead of the horse on to the ophthalmoscope.

The reflecting lamp should be held by an assistant. Lastly, the animal, if a large one, will be placed in a dark stable, if a small one, in some dark corner.

Position of the observer. The observer should be on the same side as the eye to be examined. If the right, he should seize the right ear with the left hand. If the left eye, place the left hand on the forehead of the animal so as to be in contact with it and prevent accidents from movements of the head. The ophthalmoscope, firmly grasped in the hand, is placed before the eye in the orbito-nasal angle (like a monocle). Thus it is easy to see through the sight-hole in the mirror, and as large a field of vision as possible is obtained. Placed at about 20-25 cm. from the eye (*i.e.*, at the distance of distinct vision), and at the height of the eye, the observer tries by slight movements of the head and the mirror (but without moving the mirror from the orbit) to direct a ray of light on to the cornea of the patient. Unless this pencil falls on to the cornea the membrane is dark, but it is brilliantly lit up when the rays do fall on it.

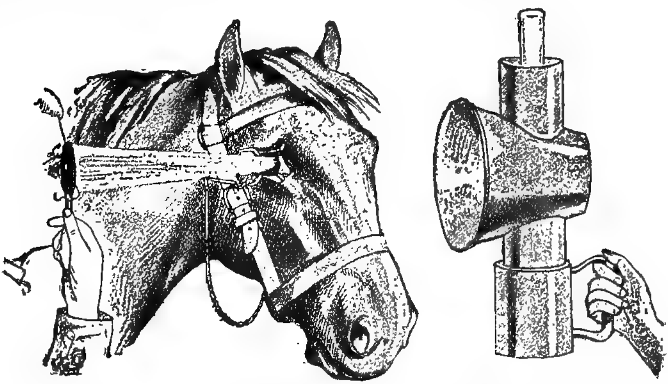


Fig. 36. Illumination of the Media by an artificial source of light. Rolland's lamp (Cadiot and Almy).

Information furnished by direct illumination. If the media are normal, the pupil is uniformly lit up and assumes different colours according to the colour of the tapetum lucidum and the portion of the eye illuminated, and therefore the portion reflecting light. In abnormal or pathological conditions of the media *opacities* can be seen on the pupillary field appearing black or grey according to their density, but never of their proper colour, such as the white, yellow, or red of exudation or hæmorrhage. They may be *fixed* or *mobile.*

Fixed Opacities. Moving with the movements of the eye and stopping when the eye comes to rest they are situated in the solid media—in the cornea or lens. They may be inflammatory corneal opacities, exudates, or cataracts on the faces of the lens or in its substance.

Diagnosis of the position of the fixed opacities may be made in several ways.

(A) *By the habit of accommodation.* If in ordinary life we wish to appreciate the distance between two objects, even though very close together, we do so from the education of our mechanism of accommodation which demands a different muscular effort to see each of the objects clearly and distinctly. It is the same for opacities of the eye, which may be situated in the cornea or in the lens, and which necessarily demand a different effort to be seen clearly. The muscular sense of the observer informs him of the position of the opacity as it does for the weight and size of objects.

(B) *By movements of the Animal's Eye.* In lateral movements, which are much more extensive and appreciable than vertical movements in our animals, the eye pivots round a vertical axis passing approximately through the middle of the lens (*see* Motor Apparatus).

From this it follows (*a*) that opacities of the cornea and and anterior lens capsule are displaced in the direction of the movements of the eye, (*b*) that opacities of the posterior lens capsule appear to move in a direction opposite to the movements of the eye.

(c) *By parallactic displacement or movement.** This principle is as follows:—Three points, P'', P', and P, appear as one to an observer placed at O (fig. 37), but if the observer move to O' these points will be seen to separate and to become projected into the pupillary field at p, O', n (fig. 37). The corneal opacity P'' seen at p will thus have drawn nearer to the border of the pupil on the opposite side to which the observer has moved. The anterior capsular opacity P' will not have moved in relation to the borders of the pupil and posterior capsular opacity P, seen at n will have drawn nearer to the border of the pupil on the side to which the observer has moved. That is to say:—*When the observer moves corneal opacities move in the opposite direction, while posterior capsular opacities move in the same direction, and anterior capsular opacities remain fixed.*

Mobile Opacities. These move irrespective of the movements of the eye and are consequently situated in a liquid medium—the aqueous or vitreous humour.

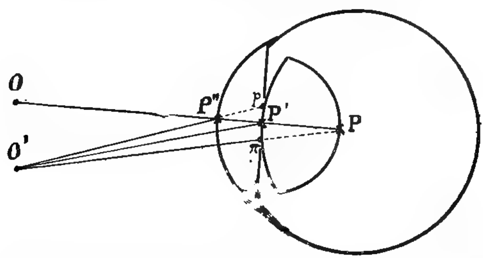


Fig. 37, Parallactic displacement in relation to the pupil.

Diagnosis of their position is made (*a*) by habit or accommodation, (*b*) by parallactic displacement or movement, and also (*c*) by their own movements. It is obvious that an opacity which moves in the pupillary field and which disappears behind the iris is usually situated in the vitreous humour, while one that moves in the pupil and is visible all the time is in the aqueous humour. Still, as Professor Macqueen

* [The phenomenon itself is termed the *parallax*.]

suggests, an opacity may be in the aqueous humour of the posterior chamber and yet be quite capable of passing behind the iris. Direct examination allows also of the examination of the anterior face of the iris and of the pupillary margin.

Examination of the Depth of the Eye. This may be carried out in two ways: by the erect or upright image and by the inverted image. *In veterinary practice the first is certainly preferable.* Its simplicity, contrary to what is the case in man, makes ophthalmoscopic examinations possible to everyone.

Examination by the erect or upright image. This method is simple, easy, and applicable under all circumstances. The depth of the eye gives an erect image to the observer, hence the name applied.

Principle. If the eye possessed no dioptric apparatus the method would in no way differ from the preceding one (examination of the media). The observer would only have to approach as near as possible to the eye to be examined, to about 5 cm, to have as clear and wide an image as possible of the fundus oculi. Just in the same way as it is possible to view the interior of a room through a keyhole much better by going close to the hole than at any distance from it.

But we know that the eye possesses a dioptric apparatus which causes emergent rays to leave in variable directions. Thus it has been shown that an Emmetropic eye gives off parallel rays, that a Myopic eye emits convergent rays, and a Hypermetropic eye divergent rays.

Now, the Emmetropic eye of an observer can, as has been said, only perceive parallel rays (not taking any account of accommodation). Thus it follows that the fundus oculi of an Emmetropic eye only will form a clear image on the retina of the observer. The fundus oculi of a H eye, or a M eye, can only be seen by the E eye of an observer by artificial means. The H eye being illuminated emits divergent rays which form diffusion circles on the retina of the observer (keeping his accommodation relaxed). By placing a convex lense in the path of the rays it is possible, by moving the lense about, to bring back the divergent rays of the H eye to a state

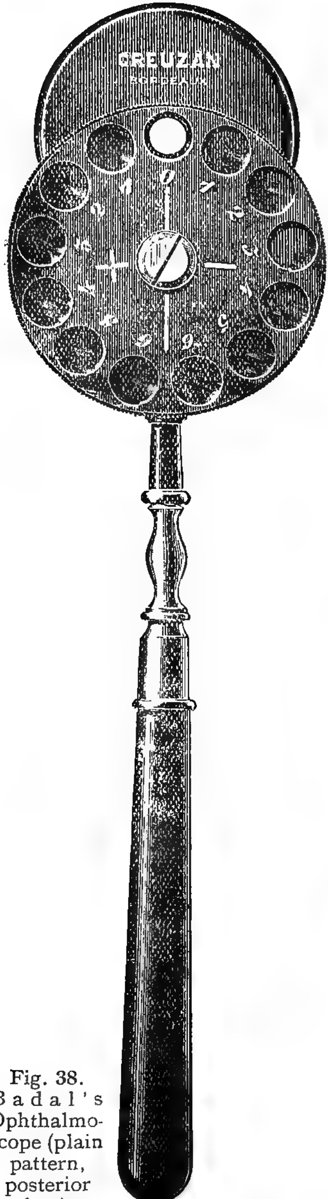
of parallelism, and when this has been done the E eye of the observer has a clear image of the fundus of the H eye. But the H eye of a *young* man possesses the power of assisting a positive lense to render parallel divergent rays which come from all external objects; this power is Accommodation. The E eye of an observer trying to see the fundus oculi of a H eye immediately has its accommodation stimulated by the divergent rays which come from H, and its dioptric apparatus is *mathematically* adapted so that the divergent rays become parallel and form an image on the retina. In consequence of the education of the human eye accommodation takes place automatically, and thus it is that in a few seconds we can see objects sending us parallel rays from a distance and objects at a distance of 25 cm.—which send divergent rays—such as the H eye. It is only necessary that the eye possess sufficient amplitude, range or power of accommodation.

A presbyopic man, forty-five years of age for example, who as a rule will not have more than 3 D of accommodation at his disposal, cannot see the depth of a H eye of 5 D. He is obliged to make use of a *convex lense* of 2 D. An illuminated M eye—the reverse of what happens in a H eye—gives out convergent rays which, in consequence, cannot form a clear image on the retina of the E of the observer, considered in a state of rest.

If the observer accommodates his eye he renders it still less capable of perceiving rays given out by a M eye. In order that the E eye of an observer can see the fundus oculi of a M eye he should be capable of diminishing his refraction—a phenomenon not possible in nature. He can only achieve his object by placing before his eye a suitable *convex lense.*

Conclusion. An E eye of the observer can see the depth of an E eye by means of the erect image, that of a H eye if he has sufficient amplitude of accommodation. It is impossible for him to see distinctly the depth of a M eye without the aid of a negative corrective glass.

Examination of the eye by means of the erect image therefore necessitates the use of an ophthalmoscope furnished with corrective glasses, hence the name *refraction ophthalmoscope.*



Refraction Ophthalmoscope. A great number of more or less complicated patterns exist. Without doubt one of the simplest is that of Professor Badal, which has been adopted in the French army; it is shown in figs. 38 and 39. Behind an ordinary ophthalmoscopic mirror a revolving disc is placed pierced near its circumference by thirteen apertures in such a way that each one can be placed exactly over the aperture or sighthole in the mirror. On one side are six positive lenses bearing the

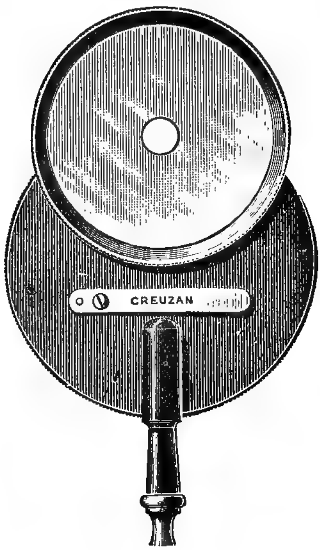


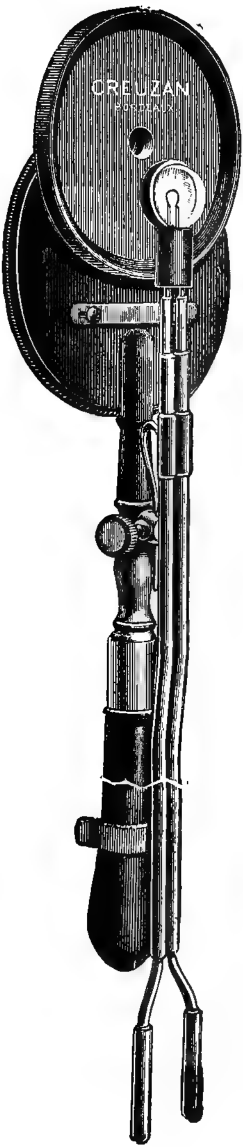
Fig. 39.
Anterior face of same.

Fig. 38.
Badal's Ophthalmoscope (plain pattern, posterior face).

numbers $+1$ to $+6$; on the other, six negative lenses -1 to -6. The thirteenth opening is free and is marked O. A slight pressure of the index finger of the hand holding the instrument is sufficient to turn the disc round and so allow any one of the twelve lenses to be placed before the eye of the observer.

Method of procedure. The animal being placed as for an examination of the media, whether in a dark room or in daylight, the observer approaches as near as possible to the eye to be examined (for reasons already stated). With a little practice with the instrument it is not necessary to first dilate the pupil, unless for a demonstration, in which case two or three drops of a 0·5% solution of atropine should at first be instilled into the eye. Contrary to what is the case in man,

Fig. 40. Method of obtaining the upright image with daylight. (Cadiot and Almy).



this causes no inconvenience to the sight, accommodation in animals being small or almost *nil*.

The pupil will be dilated if it is necessary to recognise the extent or nature of alterations of the media, or of the fundus oculi noticed at a first examination. The action of atropine being always more or less persistent it is well to have the consent of the owner before instilling the mydriatic. A horse put up for sale during the action of the drug might be considered as being unsound or suffering from an alteration of the eye.

The Orthoscope and Orthoscopy. By means of the ophthalmoscope, reflected light, natural or artificial, is thrown into the eye; with the orthoscope the apparatus itself is illuminating, and *direct rays* are thrown into the eye. This instrument was devised after experiments by Brücke. The orthoscope of Dr. Aubaret, represented in Fig. 41, consists of a little electric bulb, the size of a large pea, covered with a special metallic shade made of blackened copper which covers half the lamp and forms a frame for it—at the same time serving as a screen for the observer and a reflector for the rays of light.

An electric lamp of five, six, or eight volts is connected by a system of wires to an accumulator, or to a dry battery

Fig. 41. Aubaret's Orthoscope fitted to Badal's Ophthalmoscope.

which takes up but little room in the pocket. Fig. 41 shows Badal's ophthalmoscope fitted with an orthoscope. This means of illuminating the eye is a simplification of the ophthalmoscope because the observer need not concern himself with the reflection of rays coming from an external source of light; and also because the examination can be made in any position, whether the animal be lying or standing.

In veterinary practice, although the ophthalmoscope and the upright image is very simple, the orthoscope has the advantage of being able to be used the first time of handling without any practice. The only disadvantages of the instrument are its more complicated structure, greater weight, and higher cost as compared with the ophthalmoscope.

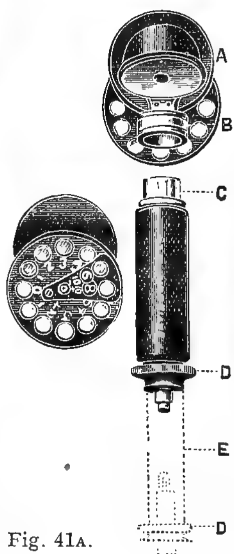


Fig. 41A.

[About three years ago the translator brought to the notice of the veterinary profession a new patent Electric Ophthalmoscope, manufactured by Messrs. Davidson & Co., Opticians, 29 Great Portland Street, London, W. It acts in a similar manner to that of Dr. Aubaret; but instead of the metal filament lamp being in front of the mirror as in the case of Aubaret's, that manufactured by Davidson occupies a place in the handle of the instrument, and the light is reflected upwards on to the inclined mirror. With this instrument retinoscopy can be performed as with a *plane* mirror or a *concave* mirror at will, and also direct and indirect examination. It is invaluable for veterinary ophthalmoscopy and for teaching purposes, and has been adopted

by the Army Veterinary Service. For retinoscopy the cap A is put on. A2 shows on the obverse side of A the lenses for examining the fundus. For retinoscopy with a *plane* mirror, the position of the lamp is close under the lense which is inside the cylinder C. For retinoscopy with a *concave* mirror the lamp should be drawn to its extremity as shown by the dotted lines. To alter the position of the lamp, grasp the part D with the thumb and forefinger, giving it a half turn to the left. This will bring the lamp into the required position for retinoscopy with a concave mirror. *Indirect* examination can also be made by placing the lamp about mid-way up the tube, and then using the ophthalmoscope with an object lense in the usual way. There are many ophthalmoscopes having electric illuminating attachments on the market which act in a similar manner to that of Davidson's. The two principal ones are Inskeep's Luminous Ophthalmoscope and the Morton-Inskeep Luminous Ophthalmoscope.]

Examination by Means of the Inverted Image. *Principle of the Method.* The depth of the eye illuminated by an ophthalmoscope can be regarded as a luminous object emitting parallel rays if the eye is E, divergent if it is H, and convergent if it is M. (Fig. 42) In the path of these rays a sufficiently strong positive lense L. is introduced; this will

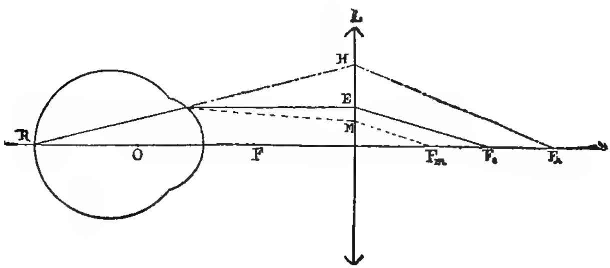


Fig. 42.

cause all the rays to converge towards the axis, and they will form a real inverted image of the fundus oculi. An E eye will form its image on the principal focus of the lense, a H eye beyond, and a M eye on the near side of this principal focus. The observer has to place himself in such a position, therefore, that he is able to see the real aërial image of the fundus oculi.

Position and Method of Procedure. Two instruments are necessary, the *ophthalmoscope*, which is used to illuminate the eye, and a *convex lense* of about 15D, with which to form the aërial image. The ophthalmoscope in general use is a concave mirror. This examination necessitates a dark room and an artificial source of light—the position is the same as for the erect image. The observer placed at about 60 cm. from the animal applies the ophthalmoscope to his eye under the edge of his orbit, and with it he illuminates the pupil. Having done so he takes the convex lense between the thumb and index finger (of the left hand), and using the other fingers to form a support on the head of the animal on the circumference of the orbit, he brings the lense in the path of the luminous rays.

He must then try to find the aërial image in front of this lense towards its principal focus, and having found the image the lense must be moved backwards and forwards till it is quite

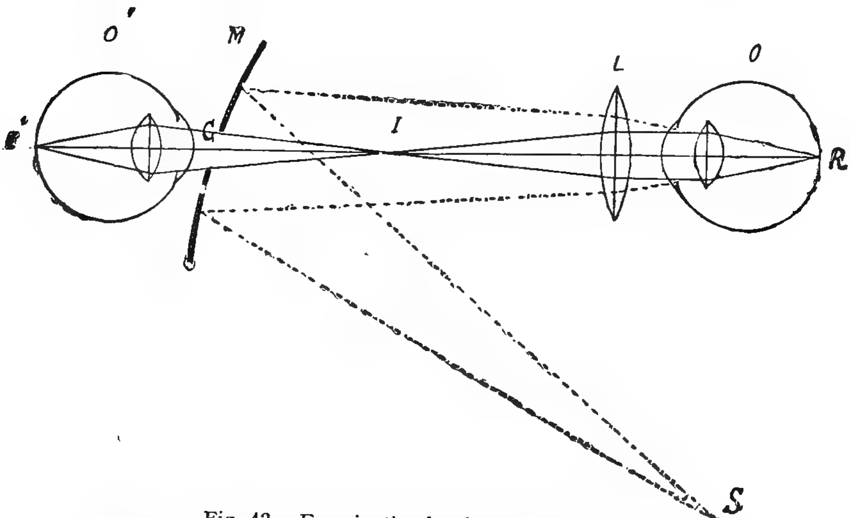


Fig. 43. Examination by the inverted image.
O'—Eye of the observer. O—Eye of animal observed. M—Ophthalmoscopic mirror. S—The source of light. The aërial image is formed at I.

clear. The image is *inverted*, and so everything on the right of the eye appears to be on the left, and a point at the bottom appears at the top, and *vice versa*. *This method is particularly applicable to human ophthalmoscopy*, but is much too difficult to apply in veterinary practice, as the inverted image is specially difficult to find on account of the almost incessant movements of the animal's head, and moreover a great deal of practice is necessary to find the image under the most favourable conditions. Vachetta has shown the fundus oculi of the horse by this method. We have never been able to see the necessity of applying this method even in small animals, especially as the method of the upright image is most easily applied to small animals, and it is only from an historical and comparative point of view that it is mentioned here.

Determination of Static Refraction. Before commencing to study this question it is interesting to enquire into the importance of such researches in animals, and whether the results obtained are worth the trouble of the means employed. It cannot be suggested that any good would come of trying to correct ametropia by means of suitable glasses, but the fact of the animal's sight being affected can be turned to advantage of the owner of the horse. It is undoubtedly true that saddle horses are fit or unfit for their work according to whether their sight is good or bad. Now, anomalies of refraction considerably diminish keenness of vision, and it is only right to enquire if such anomalies existing in a horse are sufficiently extensive to be dangerous if the horse is used for saddle work. To do this it is necessary to know whether myopia existing in a horse is of more than 4 D or whether there is, what is much rarer, hypermetropia of more than 2 D.

If the question arises with regard to a man having 4 D of myopia (which every emmetropic man should be able to see by placing a glass of $+4$ D before his eye), not from the point of view of intellectual life, with which we are not concerned, but with regard to animal life properly so-called, it must be admitted that in spite of a certain inconvenience the

actual diminution of the power of vision is not incompatible with the exigencies of ordinary life. The question thus placed does not deal with every side of the problem, a man with M of 4 D in dealing with his ordinary business may be exposed to accidents, falls, etc., which he could avoid with ordinary sight. It may be the same in the horse, and faulty vision may be the cause of broken knees and mistakes in jumping. From researches in this direction on calvary horses, Clerget found that he could get no precise results; but, to be certain, the tests should be tried on thousands of horses.

In any case this question gives scope for interesting researches, but it would be difficult to actually formulate conditions for the rejection of young cavalry horses on account of the state of their refraction. A rejection could only be made if the degree of myopia were as high as 6, 8, and 9 D—conditions which have been met with in Germany at the Veterinary School at Berlin, if the recent researches of Riegel can be taken as being correct.

Refraction in the horse from a utilitarian point of view has still another bearing. A veterinary surgeon is often asked whether shying in a horse is the result of defective vision. It is therefore necessary, as Smith has remarked, that the veterinary surgeon should be in a position to give a correct opinion.

If we have succeeded in drawing attention to errors of refraction, of the effects of which little is known, the work will not have been in vain.

By means of the Erect or Upright Image. *Principle.* In principle this is the same as that already given for the examination by the upright image, and therefore it is only necessary here to consider its application.

Diagnosis of Emmetropia and Ametropia. In the following descriptions it is supposed that the observer is E, or has been rendered so by means of glasses. He proceeds with the ophthalmoscopic examination, the instrument being at zero.

He has a clear view of the fundus oculi. Then the eye is either E or H, and in the latter case the image is only clear

if the observer has accommodated his eye. To find whether the eye is E or H, pass behind the sight aperture or hole in the ophthalmoscope a convex glass of + 1 D. If the fundus oculi appear blurred, the observer has not accommodated his eye, and the eye is E. If the eye remain clear, the observer has accommodated and at least 1 D, and the eye is H.

If there is no clear image of the fundus oculi the eye is M.

Measurement of the Degree of Hypermetropia. The fundus oculi is clear and remains so on interposing a convex glass of + 1 D. It is H, and after this first examination it may be thought that the degree of H is less than 1 D. Then pass before the sight aperture in the mirror a convex glass of + 2 D. If the image of the fundus oculi become blurred the H is not more than 1 D ($\frac{1}{2}$ D more or less). If the image of the fundus remain clear, the observer has accommodated at least 2 D, and the H is at least 2 D and so on. The last convex glass which leaves the image clear is almost within $\frac{1}{2}$ D of the degree of H. Mathematically to measure the degree of refraction sub-divisions of glasses must be used—·25 D, ·50 D, ·75 D. Now the glasses of the ordinary ophthalmoscope are only graduated in dioptries, and can only be used to measure within $\frac{1}{2}$ D, and this is quite sufficient. When the glass + 3 D leaves a clear image and + 4 D renders it indistinct, the degree of H is really between 3 D and 4 D. If then the glass + 3 D (which renders the image clear) be taken as measuring the degree of H, we only allow of an error of less than $\frac{1}{2}$ D. If the glass + 4 D (which renders the image indistinct) were chosen, the error would be more than $\frac{1}{2}$ D. On this account it may be said that the first convex glass which gives an indistinct image measures almost $\frac{1}{2}$ D more than the degree of H. In the horse it is necessary to choose between the two formulæ so as to get as near the truth as possible.

Correction to be applied to this method. This method only gives the correct measure of the H when the corrective glass is applied very close to the eye, almost against the cornea. In practice it is very difficult to approach nearer than 5 cm. to

the eye of the horse. The distance must therefore be taken into account. When a convex lense of $+2$ D is placed before a H eye at 5 cm. from it and renders the divergent rays sent out by the eye parallel, the observer (E) can consequently see the fundus oculi, *i.e.*, the principle focus of the lense coincides with the conjugate focus *r* of the retina or the remotum of the eye H (*see* fig. 44).

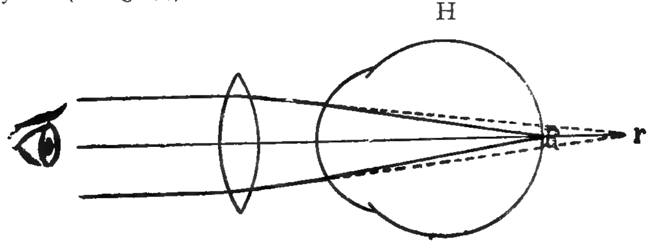


Fig. 44.

Now, the distance of this focus from the lense is $\frac{1}{2}$ metre $= 50$ cm. The remotum *r* of the H eye is found at $50 - 5 = 45$ cm. from the dioptre,* and as the distance of the remotum measures the degree of H it follows that this is $\frac{100}{45} = 2{\cdot}22$ D.

Examined at 5 cm. by the upright image the H eye appears less H than it really is.

In the example chosen above, the error $\frac{1}{4}$ D may be neglected, but it can be shown that the error increases with the degree of H, and the distance of the corrective lense.

Suppose a lense of $+4$ D placed at 5 cm. from an eye H to be the required corrective glass. The focal distance of

* In taking the cornea as the summit of the ocular diopter, *i.e.*, as the place from which focal lengths are measured, still an error is made, for these are measured, as has been seen, from the principal points. To the 5 cm. separating the corrective lense from the cornea which has been explained above, must be added the distance between the summit of the cornea and the second principal point—in this actual case it would be about 6–9 mm. But in the ordinary way such exactitude is not necessary; an approximation is sufficient, provided that it is always the same, in order that results may be compared.

the lense being $\frac{1}{4}$ metre = 25 cm., the distance of the remotum from the eye H will only be 25—5=20 cm., and the real $H = \frac{1\ m.}{20\ cm.} = 5$ D. Here the diversity=1 D, a diversity which is progressive.

Suppose now this same lense + 4 D is situated at 10 cm. from the eye H, the distance of the remotum from the eye H is consequently 25 — 10 = 15 cm., and the real H is $\frac{1\ m.}{15\ cm.} = 6$ D (about). The error is at least 2 D, and consequently increases greatly with the distance.

It is to avoid these errors regarding the distance of the correcting glass that the dioptric value of the Hypermetropia is taken as being that of the glass corresponding to the formula $H = \frac{1}{D-d}$, in which D is the focal length of the correcting glass and d its distance from the eye.

Example. The glass + 2 D at 5 cm. from the eye is the correcting glass, the H *required* is

$$\frac{1}{\cdot 50 - \cdot 05} = \frac{1}{\cdot 45} = 2\cdot 22 \text{ D.}$$

Measurement of the Degree of Myopia. The fundus oculi is indistinct with the ophthalmoscope at zero—this shows the eye to be M. Pass before the sight-hole in the mirror the concave lense —1 D. If the image become clear, the M is 1 D. If the image remain indistinct it is more than 1 D. Pass on the disc till the glass — 2 D comes before the sight-hole—the image becomes clear, and the M is 2 D, etc., etc.

The *last concave glass* which leaves the image indistinct measures within $\frac{1}{2}$ D (or less) of the degree of M.

The *first concave glass* which renders the image clear measures within $\frac{1}{2}$ D (or more) of the degree of M.

Corrections to be applied to this method. As for the eye H this measurement needs a correction for the distance separating the correcting lense from the eye observed—this distance taken as being 5 cm. as before. When placed at 5 cm. from an eye M, a concave lense of — 2 D renders the convergent

rays sent out by this eye parallel, and consequently allows the observer to see the fundus oculi clearly—this means that the principal focus of the lense coincides with the conjugate focus *r* of the retina or the remotum of the eye M (fig. 45). The focal length of the lense is $\frac{1}{2}$ metre = 50 cm. The remotum *r* of the eye M is therefore at ·50 + ·5 = 55 cm. from the dioptre, and as the distance of the remotum measures the degree of M

it follows that this myopia $= \dfrac{1 \text{ m}}{\cdot 55 \text{ cm.}} = 1{\cdot}80$ D.

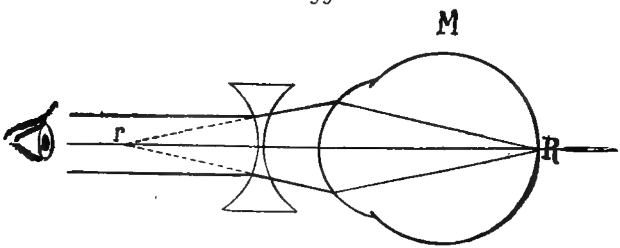


Fig. 45.

Examined at 5 cm. by the erect or upright image the eye M appears more M than it really is. The error, in excess, made in the above case is about $\frac{1}{4}$ D, and is negligible. But this error increases with the degree of M and the distance of the correcting lense as for hypermetropia. The real value of M in dioptres is given by the formula $M = \dfrac{1}{D + d}$.

Example:—If at 10 cm. the glass − 4 D corrects the myopia of an eye, this M is really $\dfrac{1}{\cdot 25 + \cdot 10} = \dfrac{1}{\cdot 35} = 3{\cdot}33$ D.

Advantages and disadvantages of this method. This method has the great advantage of being very rapid. By taking care to place himself at 5 cm. from the eye, the error made on account of this distance in ametropia of not more than 4 D is negligible if, as measure of the H, the first convex glass which renders the image blurred is taken, and for measure of M the last concave glass which leaves the image indistinct.

Under these conditions it can be used by anyone at the moment of purchase. It is particularly useful in the army as

a means of selecting between horses in which ametropia is slight and consequently does not necessitate their rejection, and those rare cases in which there is a degree of ametropia which may raise doubt as to the advisability of purchase. The simplicity of the formulæ for finding the real M and H is such that they should be no hindrance to the use of the method under any circumstances. The method of the upright image has been accused of needing an education of the accommodation only to be acquired by specialists. Now the *relaxation of accommodation* on the part of the observer is not necessary, and on the other hand the accommodation which we are accustomed to exercise in every day life should be little subject to spasm, and the observer should be able to carry out the method of the erect image on the horse without fatigue.

Lastly, the error arising from the appreciation of the exact moment at which the fundus oculi becomes indistinct or otherwise, easy to make in man, in which the vessels taken as landmarks are large with a double contour, is easier to avoid in the horse where the retinal vessels situated above the papilla are as fine as hair. This method cannot give the degree of astigmatism. Used only occasionally in human ophthalmology on account of the difficulties arising from the position of the eye to be examined, this method seems to be quite the best in veterinary practice, especially as correction may be neglected—the clinician, not having to prescribe spectacles, may content himself with an equation which may be expressed thus:—with more than x dioptries of myopia measured by the erect image, the observer being at 10 cm., any horse will be clumsy in avoiding obstacles.

The Aërial Image of the Fundus. The observer placed at 1 metre, 60 cm., 50 cm., etc., from the eye, illuminated by means of an ophthalmoscope, sees, sometimes very clearly, a part of the fundus with the details of the tapetum lucidum.

To understand this phenomenon and to turn it to account, it is necessary to recall the fact that an E eye gives out parallel rays, and so the image of the fundus is found at infinity. Also that the M eye sends out convergent rays form-

ing a real image in front of the eye, and that the H eye sends out divergent rays forming a virtual image behind the eye. It follows from these facts (1) That an E observer placed, *e.g.*, at one metre from the illuminated eye will not see the image of the fundus of an E eye, since it is situated behind him. (2) That he will see that of a M eye of more than 1 D, since it is situated at less than 1 metre from the eye. (3) That he will see the image of a H eye, whatever may be the degree of H, since it is situated in front of the eye.

Conclusion. If the image of the fundus is apparent to the observer practising direct illumination of the pupillary field, the eye is H, or may be M of more than 1 D, if he is at 1 metre, and $\frac{1}{0{\cdot}60}$ m. $\frac{1}{0{\cdot}50}$ m. $\frac{1}{0{\cdot}30}$ m. dioptries if he is at 60 cm., 50 cm., 30 cm., from the eye under examination. The question then arises is the eye M or H? This can easily be answered by the method of parallactic movements. (*See* p. 55.) In fact, if the image observed and which is projected into the pupillary field belongs to a M eye it is really situated in front of this pupillary field and is then displaced in the opposite direction to the movements of the observer—it goes towards the right of the pupillary border as the observer goes to the left. But if the image is that of a H eye it is situated in front of the pupillary field and then moves in the same direction as the observer. It must be remembered that the H may be of any degree, but that the M is always more than the inverse of the distance separating the observer from the eye observed. Nothing further need be said of this method.

The Shadow Test, Skiascopy, Retinoscopy, or Cuignet's Method. The term skiascopy, meaning "examination of shadows," is preferable to that of keratoscopy or examination of the cornea, as the phenomenon does not take place at the cornea as Cuignet believed.

When an examiner placed at 1 metre from the eye under consideration throws, by means of an ophthalmoscopic mirror, a pencil of luminous rays into the eye the pupil is

brilliantly lighted up, as has already been shown. If at this moment the observer makes a very slight turn of the handle of the instrument in his fingers he evidently displaces the luminous field in one direction or another, just as a child playing with a mirror in the sunshine displaces at will the reflected light.

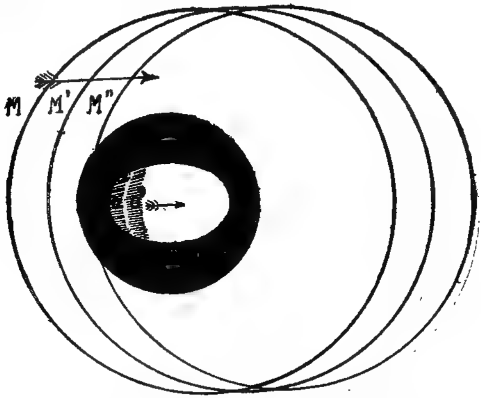


Fig. 46.—Direct shadows M, M', M'', Path of the circles of illumination made by the mirror. O, O', Course of the direct shadow in the pupil.

If the mirror, reflecting at first straight in front, is turned so that it looks towards the right or left, up or down, the surface lighted up moves in the same direction. However feebly the mirror might be rotated the eye, or rather the pupil, will always be found in the illuminated pupillary field in spite of the parallactic displacements occurring in that field, and from this the following phenomenon is observed. The pupil being well illuminated, if the mirror is moved gradually, so that it looks slightly more and more to one side, a more or less deep shadow will be seen to form near one of the lateral borders of the pupil in the form of a crescent covering the whole height of the pupil, not very broad at first, but increasing and going on till it covers the whole of the pupillary field, and then it slowly disappears towards the opposite border.

This shadow, which can be produced just as well in a vertical direction by moving the mirror up or down so that it

looks slightly upwards or downwards, is the *pupillary shadow* first observed by Cuignet in 1873.

Now the characters of the shadow are to some extent determined by the nature and degree of refraction. Amongst these characters the direction of the shadow is most important.

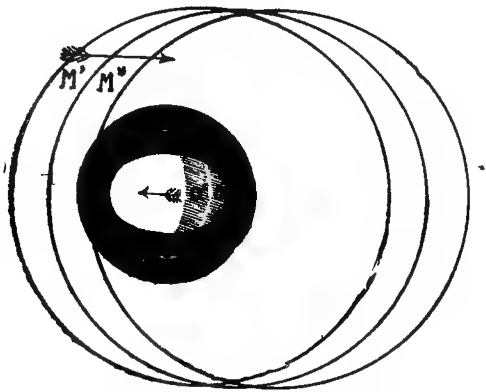


Fig. 47.—Inverse Shadows.

Course of the Shadow. The shadow is said to be *direct* when it moves in the same way as the mirror (fig. 46). Thus the mirror being moved to face more and more to the left of the operator, a shadow which moves from right to left is said to be direct. The shadow is said to be *inverse* when it moves in the opposite direction to the mirror. (Fig. 47). When there is no shadow formation, in spite of the movements of the mirror, or when the pupil is uniformly illuminated, in whatever way the mirror is moved, the shadow is said to be *nil*.

Principles of the Method. The following fact on which Cuignet's method is founded should always be borne in mind, viz., that the shadow is *nil* every time the observer is at the remotum of the eye observed. Now to know the remotum is to know the refraction. But it is always possible, whatever be the position of the observer, to cause the shadow to disappear by interposing corrective glasses before the eye observed. In other words the observer can always, by using

corrective glasses placed before the eye, make the remotum of the eye observed coincide with his own position.

It is then easy to deduce the refraction from the position of the observer and the power of the glasses interposed. Thus: suppose O to be an eye of which the refractive power is to be ascertained. Let the observer be placed at 1 metre from the eye, and also let the shadow be *nil* on placing a glass + 4 D before the eye O. At the moment the shadow disappears, the observer is at the remotum of a M eye of 1 D, since he is at 1 metre from the eye. But to obtain this result a glass of + 4 D has been employed, the refraction has been increased by this amount, and therefore there is a deficit of refraction of 3 D, *i.e.*, the eye is H of 3 D. Otherwise stated, this means that to obtain a refraction of + 1 D, + 4 D has been added, and the required refraction is obtained as follows:—

$$x + 4\,\mathrm{D} = +1\,\mathrm{D}$$
$$x = +1\,\mathrm{D} - 4\,\mathrm{D} = -3\,\mathrm{D}$$

In practice the observer places himself at 1 metre or at 5 metres. At 5 metres he is situated at the remotum of an E eye — rays which converge at 5 metres being supposed to be parallel. The problem remains as above, the figures only being different.

Example:—The observer 5 m. from the eye has obtained a *nil* shadow by placing before the eye a glass — 3 D. At the moment this shadow becomes *nil* the observer is at the remotum of an E eye. (In reality he is at the *r* of the eye M of $\frac{1\,\mathrm{m.}}{5\,\mathrm{m.}}$ D = ·20 D, but the error is negligible.) To obtain this result he has had to diminish the refraction of the eye observed by 3 D; this eye is therefore M of 3 D,

$$x + (-3\,\mathrm{D}) = 0$$
$$x = +3\,\mathrm{D}.$$

The whole of Cuignet's method is comprised in this simple reasoning.

Method of Application. *Choice of the Distance.* The method may be used at any distance, but two only are used in practice, chiefly on account of the easiness of the reasoning; 5 metres, at which distance the observer is at the remotum

of an E eye, and at 1 metre when he is at the remotum of a M eye of 1 D, but also for other reasons easily understood. To measure the refraction of an eye it is necessary that the eye does not accommodate, and on this account the patient examined—if a man—is placed in a dark room and told to look at some distant object. As he might be tempted to look at the observer, all chance of error is avoided at 5 metres. The eye of the man looked at at this distance could only accommodate $\frac{1}{5}$m. = ·20 D, a negligible quantity. The same reasons do not exist in the horse, as accommodation practically does not exist, and also these errors can be avoided by the use of atropine to paralyse the mechanism of accommodation, which also dilates the pupil and renders the shadow more easily seen. It is necessary at 5 metres to use a plane mirror to allow the pupillary field to be properly illuminated, as this is not possible with the concave mirror of an ordinary ophthalmoscope at this distance. A dark room and a lamp are necessary, and in fact a set of special instruments. Furthermore it is very fatiguing on account of the efforts of attention which it demands, firstly on account of the distance, and still more on account of the constant movements of the animal taking the pupil out of the field of vision. These are serious disadvantages which are not compensated for by the advantages gained.

The examination for the shadow at 1 metre distance, on the contrary, can be made in daylight as well as by artificial light and with an ordinary concave ophthalmoscopic mirror. If the shadows are a little less clear than with a plane mirror they are always sufficiently clear for their course to be determined.

Skiascopy at 1 metre with a Concave Mirror. The horse is placed as if for an ophthalmoscopic examination.

The observer is placed at 1 metre so that he can illuminate the eye, his ophthalmoscope being at the height of the eye to be examined, throws a luminous pencil into the pupillary field and he at once seeks to find the course of the shadow in the horizontal sense.

Three things may happen:

The shadow is nil, or in other words there is no path of the shadow. The eye is M of 1 D.

The shadow is direct. The eye is M of more than 1 D. To determine the degree of M have a concave glass of — 1 D placed before the eye by an assistant standing near the head of the horse, and again determine the path of the shadow. If the shadow is still direct have the concave glass — 2 D placed before the eye, and so on until the direct shadow is replaced by a *nil* shadow. Suppose that the glass — 2 D gives a *nil* shadow, now to have a refraction of + 1 D it has been necessary to place before the eye — 2 D, and consequently the refraction is + 3 D.

Rule. When the shadow is direct the power of the negative glass which produces a *nil* shadow added to 1 D, gives the measure of the refraction.

Examples: — 4 D gives a *nil* shadow.

Refraction = 1 D + 4 D = + 5 D of M.

— ·25 D gives a *nil* shadow.

Refraction = 1 D + ·25 D = + 1·25 D of M.

The Shadow is Inverse. The eye is then H, E, or M of less than 1 D. Then place before the eye observed a convex glass of + 1 D and redetermine the course of the shadow. Three cases may present themselves:—

(1) *The shadow becomes direct.* This means that the eye has been rendered M of more than 1 D, but as only 1 D has been added it follows that the eye must be M of less than 1 D. To find this M, replace the correcting glass + 1 D by the convex glasses + ·75, + ·50, + ·25 D in succession, and find with each of them the course of the shadow. If the glass + ·50 D gives a *nil* shadow, this means that the eye has been rendered M of 1 D. Now to obtain this result it is necessary to increase its refraction + ·50 D; the required M is thus 1 D — ·50 D = + ·50 D.

(2) *The shadow becomes nil.* The observer is then at the remotum of an eye M = 1 D; but to obtain this result + 1 D has been added to the eye.

The eye is therefore E. 1 D — 1 D = 0 = E.

(3) *The shadow remains inverse.* The eye is H. To find the degree of H, place before the eye observed a glass + 1 D, and by more powerful convex glasses + 1·5 D, + 2 D, + 2·5 D and so on, find with each the course of the shadow. If + 1·5 D gives a *nil* shadow, the observer is placed at the remotum of an eye M = 1 D, but to obtain this result he has added a glass of + 1·5 D. The required refraction is therefore :—

$$x + 1{\cdot}5\,D = +\,1\,D$$
$$x = 1\,D - 1{\cdot}5\,D = -\,{\cdot}50\,D \text{ of H.}$$

Rule :—When the shadow is inverse, the value of the convex glass which produces a *nil* shadow less 1 D gives the sign and measure of the refraction.

Examples :— + 4 D gives a *nil* shadow.
Refraction = 1 D — 4 D = — 3 D of H.
+ ·75 D gives a *nil* shadow.
Refraction = 1 D — ·75 D = + 0 ·25 D of M.
+ 1 D gives a *nil* shadow.
Refraction = + 1 D — 1 D = 0 or E.

SUMMARISED TABLE.

Direct Course. Myopia > 1 D.	Inverse Course. 1° M < 1 D ; 2° Em. ; 3° Hyp.	Nil Shadow. Myopia = 1 D.
The power of the *negative glass* which produces a *nil* shadow, *added to 1 D* gives the degree of Myopia. *Ex.* : The concave glass of 2 D gives a *nil* shadow. M = 1 D + 2 D = 3 D.	The power of the *positive glass* which gives a *nil* shadow, *subtracted* from 1 D gives the refraction and its measure. *Examples* : + 0·75 gives a *nil* shadow. Refr. = 1 D – 0·75 D = + 0·25 M. + 1 D gives a *nil* shadow. Refr. = 1 D – 1 D = 0 = E. + 4 D gives a *nil* shadow. Refr. = 1 D – 4 D = – 3 D of H.	A convex glass gives a direct shadow. A concave glass gives an inverse shadow.

Skiascopy at 5 metres with a plane mirror. The manipulations are the same, but there is no calculation to make—the glass which renders the shadow *nil* measures the refraction. It is only necessary to know that under the same conditions of refraction in the eye, the plane mirror gives shadows in a contrary direction to those obtained with a concave mirror. Thus a plane mirror gives an inverse shadow in Myopia, and direct shadows in Hypermetropia. This being the case, the shadow may give rise to three conditions :—

1. The shadow *nil* without interposing any glass—the eye is E.

2. The shadow inverse. The eye is M, the refraction is in excess, negative glasses are interposed, and if — 3 D gives a *nil* shadow M = 3 D.

3. The shadow direct—the eye is H, *i.e.* is not sufficiently refractive, and if the glass + 3 D gives a *nil* shadow H = 3 D.

Measurement of Astigmatism. Astigmatism is measured by the difference in refraction existing between the two principal meridians. This measurement can only be made with a skiascope—the horizontal meridian being measured first and then the vertical. If the horizontal meridian is E and the vertical is M = ·50 D, the astigmatism is said to be *Simple* myopic, and = ·50 D. If the horizontal meridian is M = 1 D, and the vertical M = 2 D the astigmatism is said to be *Compound* myopic and equal to 1 D. If the horizontal is H = 1 D, and the vertical M = 1 D, the astigmatism is said to be *Mixed* and = 2 D. In all these examples the astigmatism is said to be *Regular*—the vertical meridian being always more refractive than the horizontal, but if the horizontal meridian is M = 1 D, and the vertical E, H, or M < 1 D, astigmatism is then *Irregular.*

Causes of Error with the Skiascope or Retinoscope.

1. *Paradoxal Shadows.* This name was given by Leroy to those shadows met with in man in the course of shadow testing, and which were apparently not formed according to the ordinary rules. In place of a single direct or inverse shadow

two are met with, one central the other peripheral, which move in opposite directions. They may approach one another or may move away from one another "like the blades of a pair of scissors when opened or closed." Met with when the dilatation of the pupil is at a maximum, the paradoxal shadows are the result of a *Spherical aberration* of the diopters of the eye. Beyond a certain opening of angle or diameter a convex lense is, for example, more refractive at its periphery than at its centre, so much so that it has not a geometrical point for its principal focus. (Fig. 49.)

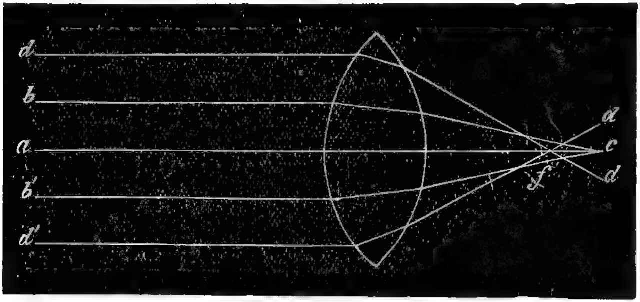


Fig. 49.—Spherical Aberration.

The diopters of the eye *may* realise the same conditions in such a way that the periphery of the pupillary field and its centre having different refractive powers, will have independent shadows, and these may move in different directions. Ballangée, who has studied in the horse "abnormal shadows," moving in opposite directions, has seen them appear at the two extremities of the diameters examined. He has reported that they depend on the diameter of the pupil and disappear on using a diaphragm or narrowing the pupil. Also that they are specially seen in myopia, and much more frequently when the myopia is of high degree and the observer is further from the eye observed; they have no connection with spherical aberration.

Under the name of paradoxal shadows Ablaire has also described a phenomenon which may be more correctly termed

Inversion of the shadow. A shadow which is direct at the first movement of the mirror becomes inverse at a second movement. He explains this as being due to accommodation in the horse, and this is not impossible, though accommodation is very limited in this animal. But as inversion of the shadow occurs after the use of atropine some other cause has to be sought for, and Nicolas and Fromaget have attributed it to the peculiar form of the eye in the horse.

Influence of the form of the eye of the horse on static refraction. We already know (Fig. 50) that CA > CB > CD. If then the retina at B is E, it will be M at A, and H at D.

Now, an observer having just found the shadow in the direction CB looks for a second along CA. Suppose at this moment the horse moves his head, the inverse shadow will at first become direct, because between A and B there will sometimes be a difference of refraction of 2 or 3 D, so that this must be carefully taken into account in using the method of the upright image.

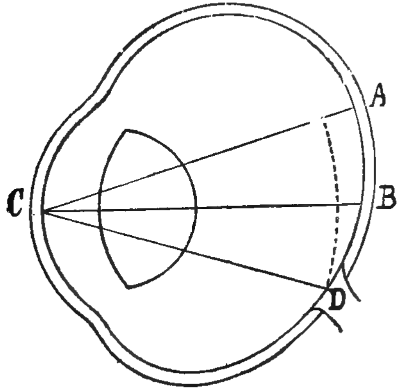


Fig. 50.—Diagram of the shape of the Horse's Eye.

In any case, the peculiar form of the horse's eye explains the variable results obtained by different observers as to the state of refraction in this animal. By the upright image there is a tendency to find the refraction along the line CD, the papilla

being in this direction, and then too great a degree of H will be found. With the shadow test and a big horse the refraction will tend to be taken along CA, and too great a proportion of M is the result. To have satisfactory comparable results the refraction must be found along CB, because this is the visual line which ends in the *area* [*sensitive area*]—the spot of greatest sensibility of the retina in animals. In the horse this region extends horizontally along the limit of the two tapeta.

Rule. In determining refraction by the upright image, it is necessary in horses to take as a guiding point the region of the fundus at the border-line of the two tapeta.

With the shadow test, the observer must take care to be always looking in the direction of the visual axis.

2. *Annular Shadows.* Everyone who has practised skiascopy in the horse has found that the pupillary field is not always illuminated in a uniform manner; concentric zones sometimes exist, alternately clear and shaded, showing inequalities of refraction of the media. If the mirror is moved the play of the shadows is such that it is not possible to determine their course. These zones of different illumination are sometimes explained by the existence of concentric circles in the lens, which are easily visible by direct illumination, and which give so distorted an image in every direction of the fundus oculi that it has quite a kaleidoscopic appearance.

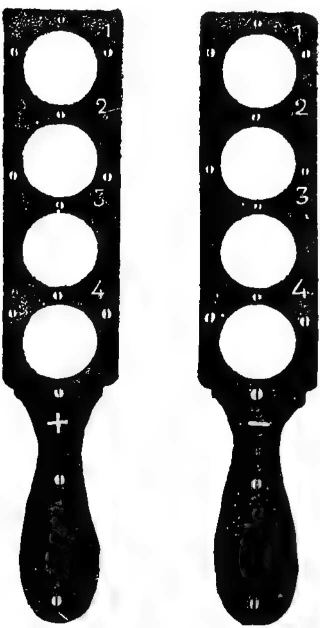


Fig. 51. Ablaire's regulating frames or "reglettes" for trial glasses for the shadow test.

Value of Cuignet's Method. The measurement of refraction by skiascopy requires an outfit consisting of a collection of graduated glasses (the oculist's case of trial glasses) which can be separately mounted on a trial frame or "reglette." (Fig. 51). The appreciation of the exact moment at which, direct or indirect, the shadow disappears is not at all easy, and in every case requires manipulations which render the method a slow one. Lastly, in the horse—chiefly on account of the shape of the eye—many serious errors may arise.

It is, however, the most mechanical method and the one most capable of giving exact results, and so is the best for beginners. Furthermore, it is the only method of measuring Astigmatism; but for the examination of horses at the time of purchase such as is practised in the Army, this method could only be made use of in cases in which an examination by the erect image had given rise to suspicions of a high degree of Ametropia.

Numerical Value of Refraction. German observers using the upright image affirm, with Berlin and Schlampp, that H is the rule in horses, and generally varies from 1 to 2 D. Only exceptionally have they met with Myopic eyes. Boden has determined the refraction of the eye of the dog. After an examination of one hundred animals of different breeds and ages, he has come to the conclusion that the normal—or what may be called the physiological refraction of the eye of the dog, is always myopic; the degree of Myopia being on an average 3 D, and varying from 1·5 to 6 D. It exists in young dogs, and does not progress with age. Attempts at correction with appropriate glasses hindered rather than improved the vision. These facts are in accordance with the somewhat feeble sight of the dog, as this animal is always guided by displacements of objects.* In France Tondeur, Carrère, Nicolas and Fromaget, Ablaire, and Froissard and Bergés using the shadow test came to nearly the same

* Boden, Uber den Refraktionszustand des Hundeauges. *Archiv für Vergleichende Ophthalmologie*, I. Jahrgang., Heft. 11, 1910, p. 195.

conclusion, viz., that feeble H (about ·5 D), and E is the normal state in the horse, and that M, though not being rare, is in the minority, (5 to 20 per cent.). Smith, in England, on the contrary finds a majority of M, whilst H and E form the exception. [Of 100 eyes examined, this authority found that 51 were myopic or astigmatic, 2 were hypermetropic and astigmatic, 6 were affected with mixed astigmatism, 39 were affected with myopia, 1 with hypermetropia, 1 with emmetropia].* More recently Riegel, examining by skiascopy

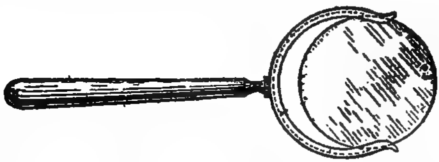


Fig. 52.—Trial Frame and Lens for the Shadow Test.

and without previously instilling atropine, found in 600 horses at the Berlin School 67 per cent. E, 30 per cent. M, and 3 per cent. H. The Myopia, which, according to the data of the preceding authors, has only rarely been found = 3 and 4 D, in the 179 cases of Riegel rose as high as 21 times = 3 D, 4 times 3·5 D, 3 times = 4 D, and the following extraordinary cases—twice = 5 D, and one case each of 6, 7, and 9 D. This author also notes that a high degree of Myopia is accompanied by *Anisometropia*, *i.e.* unequal refraction in the two eyes, *e.g.* 5 D in one eye and ·5 D in the other. Ballangée also reports one case of a horse M of 6 D. Almost all observers have remarked on the co-existence, in some cases of M in the horse, of lesions of the fundus consisting of one or more depigmented peripapillary patches, and in places some of these allow the white of the sclerotic to be seen. [According to General Smith these pigmentless patches are very remarkable, and sometimes relatively extensive. They do not appear to be associated with defective vision, but the question needs further examination].

* Proceedings of the Royal Society, Vol. 55, Aug. 1894.

These lesions have been compared to posterior sclerectasia or myopic staphyloma in man. A high degree of Myopia in man is accompanied by atrophy of the sclerotic and choroid at the posterior pole of the eye, which, diminishing the resistance of the coats, allows intra-ocular pressure to push them back. These lesions round the papilla have been noticed by Nicolas and Fromaget, and are said by these authors to be ectasias of the deep membranes, but without their having been able to determine the position of the lesions with regard to other parts of the fundus. Descriptions furnished by these authors allow the lesions to be attributed to atrophic peri-papillary choroiditis—very frequently observed even without myopia—but if there is atrophy of the choroid there is no ectasia of the sclerotic. In short, these lesions are not myopic staphylomata and have nothing in common with myopia.

Myopia is certainly accompanied by defective vision, but does this have any perceptible effect on the physical aptitude and psychic qualities of the horse? The first of these queries needs to be solved, but according to the researches of Carrère, and more recently by those of Riegel, it has been shown that defects of vision are very often accompanied by nervousness in the horse—in a word, the fear which in some horses is manifested in such strange and unexpected ways, can often be traced to defects of vision, in which Myopia plays a part. On the other hand, Nicolas and Fromaget have been unable to establish a relation of cause and effect between nervousness and defective sight. [General Smith observes that of all the horses he examined he could not say that all shying is due to defective sight, or that defective sight always causes shying].

Ablaire is of similar opinion. Motais, who has seen M in large wild animals in captivity, thinks that in them, as in man, it is the result of domestication, and of the necessity of looking at near objects. According to Riegel, myopia in the horse is independent of breed and age, which would seem, especially as regards the latter statement, to disprove the assertions of Motais.

More numerous observations would decide this point. [In the rabbit kept in hutches Myopia is the rule. It would, however, be interesting to compare this with the condition in the wild rabbit living in warrens.] Hypermetropia, generally from ·50 to ·75 in the horse, is rarely more than 1 D. In 19 of Riegel's cases three only were 1 D. Berlin and Schlampp have found some cases of 2 D.

Froissard and Bergés, in testing 650 horses, only found 3 D on three occasions! Most frequently it seems to be congenital, and is due to the form of the eye (posterior or postero-inferior flattening), but it is also acquired, and is met with in commencing atrophy of the eye, determined by inflammation of the uveal tract as has been pointed out by Nicolas and Fromaget, and Froissard. It may also be due to aphakia from luxation of the lens into the vitreous, and may then be as much as 13 D. Nothing is known of defects of vision in horses from this anomaly of refraction. [In the hare, hypermetropia is the rule; the state of refraction of the wild rabbit is not known.]

Astigmatism is to some extent a physiological state in the horse (Tondeur). In no subject examined would there be found an eye not having ·25 D of regular astigmatism which is consequently negligible. Besides this normal state, about ·75 of the eyes examined are found to have ·5 D of astigmatism, and very rarely it may reach 1 D. Simple hypermetropic astigmatism is much the most frequent; compound and mixed astigmatism are rarities. Nicolas and Fromaget have only seen two cases of irregular astigmatism.

Accommodation in Animals. In man, the power, range or amplitude of Accommodation is measured by finding the difference between the proximum and the remotum. This method needing the co-operation of the subject examined cannot be applied to animals, and the veterinary surgeon is obliged to have recourse to purely objective methods. To determine the power of accommodation in animals, it is necessary to know the refraction—first, after having paralysed the accommodative mechanism by a mydriatic, and, secondly,

after having put accommodation into play, either by contracting the ciliary muscle by means of miotics or by Faradic currents applied to the ciliary region (Heine and Hess). (1) The difference gives the power of accommodation. Heine and Hess obtained similar results on using both of the above methods.

In the Horse, Nicolas and Fromaget have obtained, by an instillation of eserine for about a week, an increase of refraction = about 1 D. In the Dog, Cat, and Rabbit, Heine and Hess have duly been able to determine a rudimentary accommodation—even in young animals the amplitude of accommodation is not more than 1—3 D on an average. The result was the same on testing a wolf. But in monkeys accommodation may be as much as 12 or 13 D. In birds (pigeons and buzzards in particular) the application of electrodes to the ciliary region produced a M of 10—12 D. By the local application of electrodes or of nicotine which causes a contraction of the ciliary muscle Heine, has been able to determine myopic astigmatism of 3—6 D. in a pigeon. The feeble accommodative power of domesticated animals, particularly of Herbivora, is in accordance with the feeble development of their ciliary muscle, the muscle of accommodation (Würdinger). In the same way the great development of the power, range, or amplitude of accommodation in birds is in accordance with the high development of the striated fibres of their ciliary muscle. The ciliary muscle innervated by the motor oculi communis (the third nerve) acts in co-operation with the sphincter pupillæ. From this it follows that accommodation (near vision) is accompanied by a contraction of the pupil, and reciprocally relaxation of accommodation (for distant vision) is accompanied by mydriasis. But in dogs near vision is accompanied by mydriasis and distant vision by miosis. This paradox of the pupil is easy to recognise, but does not seem to have ever been explained. (Müller).

(1) Heine and Hess. Von Graef's *Archiv f. Ophthalmologie*, 1898, Vol. XLV. and XLVI. *Anal.* in *Annales d'Oculistique*, t. 126.

Tonometry. The eye possesses a certain tension or consistence which is nearly always the same under physiological conditions. But this normal tension diminishes or increases in certain affections of the eyeball. The study of ocular tension is called tonometry. The condition of the eye with regard to tension can be determined by palpation with the fingers in the same way as fluctuation in a sac containing fluid is discovered.

Place the two index fingers on the eyeball upon the upper eyelid, and press the eye into the floor of the orbit with each finger alternately. To have a better idea of the pressure, the other fingers should be applied to the rim of the orbit. In estimating the state of ocular tension it is always well to compare the suspected eye with the other eye if this is healthy, or with the eye of an healthy animal of the same species. Normal tension is represented by the sign T.

Tension is increased (hypertony) in glaucoma, hydrophthalmos, intra-ocular tumours, etc. This is represented by the signs T + 1, T + 2, T + 3, according to the degree of hardness of the globe.

Tension is diminished (hypotony) with inflammation of the uvea, in which it is one of the most constant symptoms, and sometimes in inflammation of the cornea. It is denoted by T − 1, T − 2, T − 3, according to whether the eye has lost a little of its tonus, is soft, or very soft. Hypotony is generally due to softening of the vitreous humour, and especially to its atrophy and shrinking. It is very rare for a diminution of tension T − 3, not to be accompanied by some detachment of the retina, and thus to be an indication of complete loss of the eye from a functional point of view.

The state of ocular tension ought to be carefully estimated in all affections of the eye, as it is as much a symptom as an important prognostic element.

Examination of the Visual Function. In man, acuteness of vision in each eye can be measured with great accuracy by subjective methods. In our animals, and in the horse in particular, information which can be obtained with regard to

this point cannot in any way be compared to that available in man. It is possible, after a brief examination, to determine whether a horse can or cannot see. It is only after daily examination of an animal that it is possible to say that its power of vision is diminishing. In other words, the veterinary surgeon is completely at the mercy of the past history of the disease, which is often doubtful on account of the persons from whom it has to be obtained.

But there is in certain reflex objective phenomena—palpebral and pupillary—a means of control which in certain cases may be absolute. In the second place comparative ophthalmology gives proportions which exist between the visual function and alterations in the eye—theoretical information *à priori* it is true, but still it may suggest experimental work from which the truth of suspicions may be confirmed.

A certain ocular lesion in man is accompanied by a diminution of power of vision. Comparative physiology allows it to be admitted *à priori* that the same thing may happen in animals, and we have then to try to find out whether this is the case, and to what extent it affects the usefulness of the animal.

Reflex of Palpebral Occlusion. This has for a long time been known to veterinary surgeons, and its use has been, and still too often is, their only means of investigation, and the sole criterion of visual capacity—in spite of its small diagnostic value. It is a reflex of protection having its origin in the sensitiveness of the retina, and it is produced every time an object is rapidly advanced in the direction of the eye. The reflex closure of the eyelids can be produced with the hand, usually after having attracted the attention of the animal by a light tap on the face. The lashes should be avoided, as also should exaggerated movements of the hand, which may cause too great a current of air, producing a closure of the eye from a corneal reflex. To avoid this cause of error, Berger (in man) recommends placing in front of the eye a clear piece of glass and throwing a small paper dart against it. The result of this examination need only be considered negatively, *i.e.* if

occlusion is not produced, in which case amaurosis will be suspected.

Photo-Motor Pupillary Reflex. Like the preceding, this method depends on the integrity of the functions of the retina. The anatomy of the reflex will be explained later—here the method of applying, observing and interpreting it will be dealt with. It consists in a constriction of the pupil under the influence of an increase of light and a dilatation when the light is removed. It is produced at the same time in both eyes when light is thrown on to one of them. In the eye illuminated the reflex is said to be direct, and in the non-illuminated eye it is said to be crossed or consensual.

(*a*) *Direct Reflex.* Place the animal in a doorway or in the light of a window, the eye to be examined being turned towards the light in such a way that the pupil is not affected by reflections from the cornea. Close the opposite eye, this being done (by means of the thumb and first finger lightly placed on the eye to be examined), alternately open and close the eyelids, allowing an interval of a few seconds between each movement. If the retina is sensitive to light, the pupil will dilate when the eye is shut and constrict when the eye is opened. If, on the contrary, the retina is insensitive the pupil remains fixed.

The direct pupillary reflex, easy to obtain in the cat and dog on account of the amplitude of movement and its quickness, requires more care in the horse in which the movement of the pupil is slight and limited; in the case of the horse particular attention is directed to the increase or decrease in the size of the vertical diameter.

(*b*) *The Crossed or Consensual Reflex.* This is best obtained by means of an ophthalmoscope in the horse, in which it is clearer than the direct reflex. Place the animal as for an ophthalmoscopic examination. An assistant closes the eye turned toward the light, whilst the observer examines with the ophthalmoscope the pupil of the opposite eye, situated in penumbra. Then telling the assistant to open or close the eyelids the observer is in the best position for seeing movements of the pupil. When the crossed reflex exists the pupil

examined contracts when the lids of the opposite eye are opened, and it dilates when they are closed. When the crossed reflex is abolished the pupil examined remains fixed whether the opposite lids are open or closed. In the dog and cat the animal should be placed in a dim light and the observer will open and close the lids of one of the eyes while he examines the reflex of the pupil of the other. This reflex should be looked for in each eye separately. [In the dog this bilateral reflex is not observed when one eye is turned to the light and the other eye is in the shade.]

Diagnostic Deductions to be drawn from the Examination of the Photo-Motor Reflex. In man, according to Berger, these are as follows. (They are applicable to animals, having been partly drawn from experiments on animals by Bach and Meyer).

(*a*) The existence of the reflex established successively in each eye indicates that the retina and tracts of nervous conduction are normal or only slightly altered.

(*b*) "The pupil on the side exposed to the light does not contract, but that on the other side contracts normally. On changing the side of illumination the consensual reaction is not produced." The retina and paths of conduction are not altered, but a lesion exists in the "innervator nervous apparatus of the pupil of the side first examined." This is a case of *paralytic mydriasis*, which may be central in origin or caused by a peripheral lesion of the common oculo-motor or third nerve.

(*c*) "The pupil of the side exposed to the light does not contract, and there is no consensual reaction, whereas the exposure of the other pupil to the light determines a pupillary contraction in both eyes. This disturbance is seen in lesions of the retina or optic nerve which produce complete monocular blindness." This may be a case of embolism of the central artery or of monocular papillary blindness.

(*d*) "Lastly, there is the case in which the consensual reaction is no longer produced whichever be the eye illuminated. This always points to a *lesion of the peripheral or central*

nervous system." The diagram (fig. 53) procured from experiments on animals allows the preceding phenomena to be followed.

The Reflex of Convergence. When a man looks at a distant object his pupils are slightly dilated, but if he fixes his eye on his finger placed at about 25-30 cm. from the eye the pupil contracts; this is the reflex of pupillary convergence. It is independent of the photo-motor reflex. Complete absence of the photo-motor reflex with the conservation of the reflex of convergence constitutes in human medicine the *Argyll-Robertson sign*, which is of the greatest value in the semiology of central alterations of the nervous system of a syphilitic nature (locomotor ataxy, general paralysis). The reflex of convergence exists in all animals possessing binocular vision, but it is only possible to detect it satisfactorily in the dog [and Simian apes]. It may be shown by making the dog fix its eyes on some distant object, *e.g.*, by throwing a stone while holding the dog, and then bringing a piece of sugar before the animal's eyes. As has been mentioned, in this animal the reflex is inverse—the eye is contracted in viewing distant objects and dilates for near objects (H. Müller). Hendrickx and Liénaux have seen a case of locomotor ataxy of of medullary origin in the horse—the photo-motor reflex being present, and that of accommodation and convergence being absent [? Nicolas].

In Fig. 53 the centripetal pupillary fibres coming from the retina and contained in the optic nerves are marked in continuous lines with arrows. They leave the visual fibres of the optic nerve after the external corpora geniculata and go to the nuclei of of the common oculo-motor or 3rd nerve situated on the floor of the fourth ventricle. The centrifugal pupillary fibres of the common oculo-motor are marked by dotted lines and arrows. The course of the *direct pupillary reflex* can thus be easily followed. The *crossed or consensual reflex* is brought about by means of nervous communications transversely binding between them the right and left ventricular nuclei of the common oculo-motor.

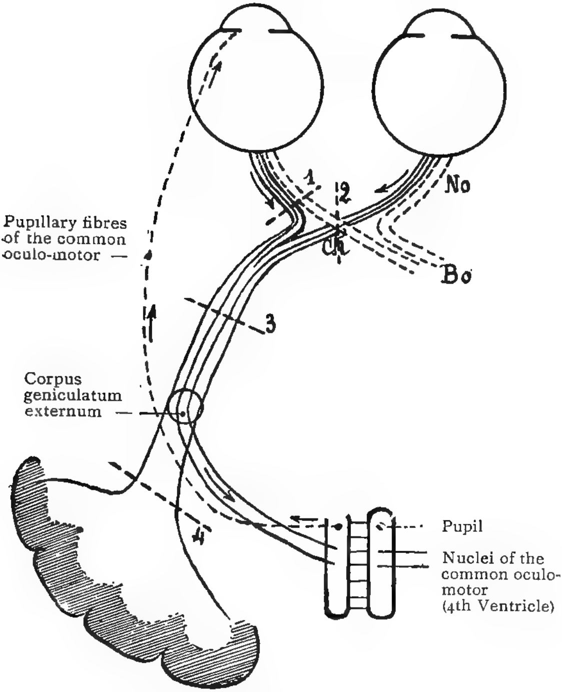


Fig. 53.—Diagram of the Pupillary Reflex Arc (after Fuchs).

(1) *Section of the Left Optic* (following the dotted lines):—Blindness on the left side—pupils equal. No direct photo-motor reflex on the left, and no crossed reflex on the right. Illumination of the right eye causes contraction of both pupils.

(2) *Section at the border of the Optic Chiasma*:—Pupils equal, pupillary reflexes retained. Sensation in the retina is lost in the two nasal halves, and the power of vision is lost in the corresponding (temporal) regions of the visual field. This symptom (loss of half the visual field) is difficult or impossible to show in animals—it is technically known as hemiopia or hemianopsia.

(3) *Section of the Left Optic Tract*:—Hemiopia, optic reflexes remain but act through the right optic tract.

(4) *Section of the Optic Fibres behind the External Corpora Geniculata*:—(*a*) On one side hemiopia with presence of reflexes; (*b*) On both sides double blindness with presence of reflexes.

Section of centripetal pupillary fibres between the external corpora geniculata and the ventricular motor nuclei:—(*a*) On one side, sight preserved and pupillary reactions normal. (*b*) Both sides, sight preserved but the photo-motor reflexes are abolished, though the reflex of convergence or accommodation is present (*Argyll-Robertson sign*).

The loss of the reflex of convergence always exists in man in cases of paralytic mydriasis due to a paralysis of the third pair of cranial nerves, or to instillations of a mydriatic collyrium (Berger). Bach and Meyer have shown that it is the same in the dog.

Information gathered from Comparative Ophthalmology with regard to the determination of acuteness of vision in different alterations of the eye. A simple definition of the principal subjective symptoms is given below.

Amaurosis (Glass Eye or Gutta Serena of Old Authors). This means loss of sight. It is seen in atrophy of the papilla, extensive lesions of the macula, etc. When no extensive lesion can be found explaining amaurosis the effect is taken for the cause. [This term is, however, gradually falling into disuse since the ophthalmoscope can now determine a great number of the lesions giving rise to it. Still it is retained to designate that condition when no lesions can be discovered.]

Amblyopia. This means diminution in the power of vision. It is seen in lesions of the deep membranes, of the nervous system, or in anomalies of refraction. [In human ophthalmology it is generally retained for those conditions of dimness of sight that cannot be relieved by the use of spectacles, and for which the cause cannot be ascertained].

Photopsia. Subjective sensations of light provoked by mechanical or pathological stimulation of the retina. Seen in cases of compression of the eyeball (Phosphenes)—tumours, exudative choroiditis, retinitis, etc.

Myodesopsia or Muscæ Volitantes. The muscæ volitantes, which are explained by their name, are generally the result of bodies floating in the vitreous humour. Choroiditis, cyclitis, retinitis, papillitis, hæmorrhages into the vitreous, foreign

bodies, parasites, persistence of the canal of Cloquet—any of these may give rise to them.

Scotoma. Dark spots in the visual field. Seen in neuritis and optic atrophy, retinitis, choroiditis, and myopic staphyloma. The papilla or punctum cæcum forms a normal scotoma, as shown by Mariotte's experiment.

Hemeralopia (*night blindness*).* The sight being good during the day but becoming bad at night is symptomatic of general weakness, but may be seen in peripheral opacities of the cornea and lens, and also in peripheral retinitis [in the dog in luxation of the lens], etc., In the evening the intensity of the rays being lessened the pupil dilates to admit a greater number so that the sight may remain good, but if the site of the lesion hinders the peripheral rays from being seen, vision obviously becomes worse.

Nyctalopia (*day blindness*). This is the reverse of the preceding condition. Vision is better at night than during the day. Met with in central lesions of the pupil, lens, choroid and retina. This is easily explained, since a bright light falling on the pupil and contracting it makes the central rays fall on affected regions, whilst in the evening pupillary dilatation allows the peripheral luminous rays to fall on healthy parts.

Functional Examination of the Animal. A blind horse, or one attacked with a high degree of amblyopia, is not long in attracting the attention of the driver who can, as a rule, give sufficient information. The animal is clumsy, blunders into obstacles, has difficulty in finding the place at which he is accustomed to drink, etc. A quick examination confirms *de visu* this anamnesis; left to himself in the riding school or yard the animal remains motionless or only moves slowly and carefully; he can be led by the bridle against a wall and strikes his head against it. Place in his path a bale of straw

*The terms Hemeralopia and Nyctalopia are used by French and other Continental ophthalmologists in the opposite sense to the common English acceptation of them. The translator has, however, retained them as in the original, but has bracketed the English equivalents so as to make them agree with the description in the text.

or a pile of brushwood and he will overturn it without attempting to avoid it. In this case diagnosis is easy; if the animal is suspected of having lost the sight of one eye repeat the above experiments after covering each eye alternately with a hood, with movable eyepiece, and so find the eye affected. If there is only diminution in the power of vision, the horse will act differently, and here it is that the observer has to bring some perspicacity to bear on the question. The horse may be let loose in a riding school in which some hurdles or bars of wood have been placed on end.

If this method is considered too dangerous he can be lunged slowly against various obstacles, first allowing him the use of both eyes and then covering up each eye alternately and repeating the lungeing. Under these conditions, if, after two or three attempts the animal makes the same mistakes and overturns the same obstacles with his knee or forearm, without sufficient manifest attempts to avoid them, the presumption of amblyopia becomes a certainly. If the horse is ridden the rider may direct him carefully into situations from which the suspicion of amblyopia can be confirmed. The same method, adapted to each species, may be applied to the other domesticated animals, to determine the condition of their visual powers.

CHAPTER IV.

THE OPHTHALMOSCOPIC EXAMINATION OF A NORMAL EYE.

The media in a normal eye are perfectly transparent. The deep membranes must be studied separately and in each animal.

Horse. Before using the ophthalmoscope a *naked eye examination* should first be made. To do this, start with one eye, following the meridian perpendicular to its antero-posterior axis, or, if possible, parallel to the edge of the cornea. The internal wall of the posterior hemisphere is represented in miniature by a picture which will readily be illuminated by the ophthalmoscope. This picture, of a brownish tint, more or less deepened at its periphery, shows in the middle two clear zones; the upper and larger, semi-circular in outline with an horizontal base, reflects in a varying manner a mixture of blue and green shades. This is the *tapetum lucidum*, so called in contrast to the rest of the fundus which forms the *tapetum nigrum*. The other zone, situated immediately below the inferior limit of the tapetum lucidum, is small, elliptical, white or pinkish in colour, and from it emerge many fine vessels—this is the *optic papilla* or disc, or point of entry of the optic nerve.

With an *ophthalmoscope* the whole of the fundus oculi cannot be seen at once—just as the whole of a room cannot be seen by looking through the keyhole. But to see as much as possible at once the observer should approach as near as possible to the pupil and then direct the cone of light in every direction.

Looking horizontally into the pupil the tapetum lucidum can be recognised by the brilliancy of its colouration, which

is very much brighter than when it is viewed by the naked eye. By stooping down to look up into the eye little bands can be seen, far apart at first, and then nearer together, chestnut brown in colour, sometimes intersected with purplish streaks or red bands—this is the tapetum nigrum. By leaning slightly forward to look backwards, or *vice versa*, the extreme lateral limits of the two zones can be seen. By gradually raising himself on tip toe to look more and more downwards the observer can see the interior limits of the two tapeta in the form of a horizontal straight, more or less pigmented border; then a little beneath this the papilla or disc (very much magnified) can be seen surrounded on all sides by the tapetum nigrum. The cornea and lens act as magnifying glasses and make the image of the fundus oculi look seven or eight times larger than it really is, as has already been stated, (See p. 27), and this allows every detail to be examined. (Plate I.)

The tapetum lucidum, a veritable mirror of the fundus oculi, shows a varying background on which little deeper coloured points or streaks stand out, usually blue or green, sometimes pink. The diversity in the number and association of these colours, in their distribution and intensity gives the fundus oculi a varying aspect—varying according to the individual, or even in opposite eyes of the same individual, or in the same eye from one point to another. With the idea of fixing them in the mind and putting them in some order, Nicolas and Fromaget have created the following types of tapeta: yellow, yellowish-green, green, yellowish-blue, many-coloured. The first is most often sulphury yellow in colour, with here and there yellow-ochreous spots scattered on the surface; darker ocellated, green or blue spots often star the tapetum—commonly situated in the centre of these ochreous spots. This arrangement resembles a chessboard with yellow divisions and blue or green centres. (See plate VI., fig. 1). The effect is still more striking when the fundus is green or blue, as in the yellowish-green or yellowish-blue types. In these two last, which are the most frequent the colours are

differently associated, and it can be imagined that the extremes may be yellow, green, or blue while the intermediate examples will be varying mixtures of these shades.

The green tapetum is, as a rule, clear with darker spots.

It is the same with the blue type in which slightly purplish (sometimes pinkish) shaded spaces are found—especially at the periphery. The stippling or dotting varies little, and it is generally green or blue, but it may be yellowish or pink. In some cases, particularly with a purplish-blue tapetum the ocellations present a tail, and look like commas or green and blue streaks bordered with a red margin. By a multicoloured tapetum is meant one showing all these colours (blue, green, pink, red, yellow, etc.) (See Plate IV., Fig. 2). On the surface of the pink zone scattered points or lines of deeper red—sometimes diffuse, in others sharply limited—can be seen standing out well marked by their deeper coloration. We have seen red striæ symmetrically placed on each side of the middle line, giving a penniform aspect. At other times they form stars. [General Smith has observed that the pigmentless fundus of the piebald and albino horses yields a wonderful red or yellow colour scheme, and a beautiful object of study].

All the images of the tapeta in which red or pink colours are seen result from absence of the fundamental layer of the tapetum (see Anatomy of the Choroid), or a diminution in thickness, allowing the diffuse red colour of the choroid and sometimes the network of its vessels to be seen through.

Contrary to the opinion of German authors, Nicolas and Fromaget have not found any relation in the horse between the colour of the coat and that of the tapetum.

The tapetum nigrum owes its colour to two elements, the pigment of the retina and of the subjacent choroid. Above and on the sides of the papilla (rarely below), the persistance of the fundamental layer of the tapetum lucidum forms a green and blue background which allows the rarefaction of the pigment to be seen. Below, the tapetum nigrum is sometimes purplish-brown in colour, and the abundance of pigment

does not allow it to be easily illuminated. Sometimes it may even happen that an exact idea of the region examined cannot be obtained, but a single point of depigmentation, which is often seen, is sufficient to allow the black surface to be at once brilliantly lit up. Sometimes it reflects a diffuse red tinge (brick-red or lilac-red tint), which is tempered with a granular brown lining, and which sometimes extends all round the papilla. This glowing base of the tapetum nigrum, which must not be taken for choroidal congestion, is sometimes very distinctly outlined by red bands of 2–3 mm. in width and of varying lengths, appearing to be in relief on account of a border of pigment, derived from the choroidal vessels. The glowing aspect of the tapetum nigrum arises from the transparency of the layer of large vessels of the choroid, and not from a particular shade of pigment. This can be proved by the following experiment:—compress the eyeball above the upper eyelid with one or two fingers of the left hand, and at the same time continue the ophthalmoscopic examination. The circulation being thus hindered, the vessels of the retina disappear, the papilla becomes white, and the red colour of the tapetum nigrum considerably paler.

The papilla, or disc, is the point from which the fibres of the optic nerve spread out. To see it with an ophthalmoscope the observer must look a little downwards and backwards, *i.e.*, towards the temporal region. Elliptical in form, it measures by the upright image about 3–4 cm. in its horizontal diameter, and 2–3·5 cm. in the vertical. Exceptionally, it is almost circular, more or less irregular; flattened from above to below, or only on its lower border when it appears almost semicircular.

Its great diameter is sometimes inclined on the horizon so as to form an arc of 90° (Moquet). We may add, however, that this arching is sometimes the result of astigmatism, and can then only be apparent and not real. Its general colouration varies according to the individual from bright red to a pale salmon pink, which makes it necessary to diagnose papillary congestion and pathological pallor with much care.

Three zones can be recognised in the papilla: *peripheral, intermediate* and *central.*

The *Peripheral zone,* which is whitish in colour, surrounds its whole circumference like a ring. It is continued upwards in the middle of its lower border towards the centre, this continuation forming a strongly light-reflecting triangular area, whose summit stands up like a tooth in the centre of the papilla. In some eyes a similar "tooth" exists in the choroid. The whitish ring represents the cellular sheath of the optic nerve, and the deeper projection or tooth is without doubt a trace of the fœtal optic cleft.

The *Central zone,* yellowish-white in colour, forms a network cicatricial in appearance, and constitutes the *lamina cribrosa.* Near the centre occupying the meshes of the network are two or three bright red spots standing out from its base; in these can be distinguished, by slight movements of the mirror, or by interposing correcting glasses, a net-work of fine capillaries.

The *Intermediate zone* is red in colour, becoming paler towards the centre. Here the vascular capillaries are very abundant, and this zone seems to contain the greatest part of the nervous fibres which go to form the retina. On this account it is slightly more salient than the centre of the papilla.

Scleral and choroidal rings. Around the papilla there somewhat frequently exists a more or less complete ring, representing anatomically the border of the sclerotic, and called the *scleral ring.*

When complete it is always a little thicker above than below, and its excentric border is sometimes bosselated. If incomplete, it is somewhat crescentic in form and may appear 5–6 cm. thick by the upright image; most commonly it surrounds the upper half of the papilla—rarely other parts of its circumference. The scleral ring reflects light strongly. It is yellowish-white, bluish-grey, or even clear sky blue in colour. Its lamellar aspect, with black spots and streaks, sometimes clearly indicates its origin. It must not be taken for a posterior staphyloma. The accumulation of pigment

bordering the scleral ring, known in human ophthalmology as the choroidal ring, has been seen in the horse, but only rarely.

Vessels of the Retina. In the horse these emerge from the periphery of the papilla—rarely at its centre, and in the latter case they may show *interruptions in their continuity*. They are often double and flexuous, sometimes spirally twisted, but are not distinguished into venous and arterial. The vessels of the retina divide dichotomously and do not anastomose; they are more abundant, longer, and thicker at the sides, where they measure about one transverse papillary diameter, than above and below where they are not more than $\frac{1}{2}$ or $\frac{3}{4}$ the vertical diameter. In the inferior region, corresponding to the fœtal cleft, they are almost absent.

Ass, mule, [*and the wild equidæ*]. The fundus presents the same peculiarities as in the horse. On account of the situation of the eye in the mule, whose cornea looks more in a downward direction, the papilla is found higher than in the horse, and immediately falls under the exploratory rays of light.

Ox. The *tapetum lucidum* shows a beautiful brilliant green colouration without any clear stippling. It extends over a wider area of the internal ocular wall, and it is necessary to look quite in a downward direction to see the *tapetum nigrum*, which is not quite so dark as in the horse.

The *papilla*, situated in the *tapetum nigrum*, quite close to the limit of the two zones, has a very irregular form. It is relatively small, ill-defined, and of a whitish tint. The chief feature making it recognisable is the point of emergence of the *vessels of the retina*. Unlike those of the horse, the retinal vessels only form three principal clusters (one superior and two infero-lateral), and they arise from the centre of the papilla and extend as far as the ora serrata. It is easy to distinguish the veins from the arteries. The veins, dark red in colour, are enormous, measuring 3-4 mm. in diameter by the upright image. The arteries are finer, redder, and wind spirally round the veins. [In the Indian ox the arteries and veins run

parallel to one another]. The arterial or venous ramifications leave or meet the principal trunks almost at right angles. (Plate II., Fig. 1).

Sheep. In this animal, the appearance of the fundus is exactly the same as in the ox, with a few variations in the distribution of the vessels. The tapetum lucidum (usually green) may be sky blue in colour (Vachetta).

Goat. The *tapetum lucidum* shows several colours, blue with purplish areas predominates; the circumference of the papilla is yellowish. In a he-goat Vachetta has seen a brilliant golden-yellow tapetum lucidum. [According to Lindsay Johnson it is lilac-coloured]. The *tapetum nigrum* is not deeply coloured, nor is it sharply separated from the *tapetum lucidum.* Through the scanty pigment of this region the bluish base of the choroid with some yellow islets can be seen. The *papilla*, situated in the *tapetum lucidum* in the midst of a yellowish zone, is only, as a rule, well-defined on one-half of its circumference, the rest being diffuse. Its general form, however, is that of a circle. Its colour is bright red; to find it, one of the vessels of the retina should be followed.

The retinal vessels start from the centre of the papilla. Red at the surface of the optic disc they become blackish outwardly, and are ill-distinguished by their colour into arterial and venous. The veins are much larger than the arteries, however; sometimes the vessels are bordered by a clearer yellowish line; their distribution is irregular, and unlike that of the ox and sheep. (Plate II., Fig. 2).

[*Dromedary*, *Bactrian camel* and *Llama.* Neither has any peripheral zone, nor tapetum lucidum, nor tapetum nigrum. The fundus is of uniform colour, and the choroidal vessels can be seen. The fundus of the camel is brownish-red and scattered all over with slightly dark grey stipplings. The papilla is cupped, and opaque nerve fibres radiate horizontally and vertically from the papilla, while a vessel-less zone with opaque nerve fibres and ocellations extends as a horizontal line just above the papilla. The vessels wind spirally round one another as in the ox. The *Llama* has a large, somewhat

oval papilla. The fundus is a very bright fuschia-red colour, covered with a few dark red choroidal vessels, and dotted all over below the papilla with dark red spots. It has no opaque nerve fibres].

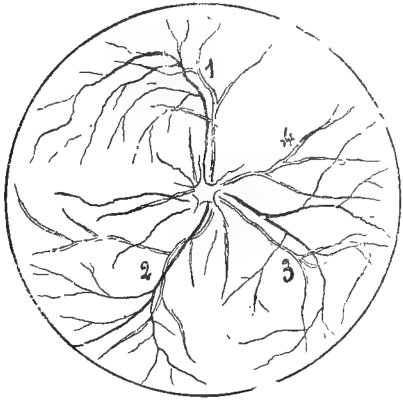


Fig. 54. Retinal Vessels of a Dog (after Bruns).

1. Superior nasal vessels.
2. Inferior nasal vessels.
3. Inferior temporal vessels.
4. Superficial temporal artery.

Dog. In the dog, the *tapetum lucidum* is not uniform in colour. Usually golden-yellow in the middle, it becomes a brilliant green at the periphery; at other times it is yellowish-blue, or carmine-red with disseminate green patches. [The tapetum lucidum varies in dogs a great deal. Often it assumes the colour of the coat; thus, in the harlequin or spotted Great Dane it appears of a slatey grey or darkish colour, simulating in distribution that of the coat; in the chocolate Pomeranian it is frequently of a chocolate colour, or even may be devoid of pigment. In many respects this latter peculiarity resembles that observed in the pure-bred cinnamon or cinnamon-bred canary. In the Chow-chow it is very commonly of an orange-red, blackish towards the periphery, and covered with bluish or bluish-green patches.

There is no doubt this variation has to do with artificial selection and in-breeding. The study of this from an ethnological or Mendelian point of view would prove of great interest].

A fine green dotting is sometimes met with.

The *tapetum nigrum* varies from a bright chestnut to the deepest brown. Superiorly, the pigment of the retina is rarefied, and is disposed in the form of small masses allowing islets of the tapetum lucidum to be seen between them. This region, more or less wide in area, gives the appearance of a most beautiful mosaic—the darker parts of which seem to stand out on the coloured portions. [As in the case of the *tapetum lucidum*, it is subject to great variations in colouring].

Sometimes, as in man, the pigmentary layer of the retina is extremely rarefied throughout its whole extent and allows the red colour of the choroidal membrane to be seen. (Plate III., Fig. 1.) In these cases the pigment of the choroid may be grouped in the intervascular spaces to form dark bands limiting the brighter red vessels. The *papilla* is situated sometimes at the upper part of the tapetum nigrum, at others at the lower limit of the tapetum lucidum, or else on the limits of the two zones. In shape it is very variable—circular, elliptical, oval, or triangular with rounded angles; we have often seen a trilobate form rather like a trefoil. Its colour varies from white to dark grey; a darker spot is very often seen in the centre—the starting point of the vessels and the result of a physiological cupping. Its border is sometimes clearly defined by a darker line which may be finely denticulated—this is probably due to "opaque nerve fibres."

The retinal vessels are distinguished into venous and arterial, and start from the centre of the papilla. The first form three trunks in the form of an inverted Y. Viewed by the erect image their dimensions are considerable, and they have been seen measuring 3–4 mm. in diameter. They are deep red in colour, sometimes uniformly spotted with purple; others again may show a clearer central region. The arteries measure 1–2 mm. in breadth; they are redder, more numerous and

spread out fairly regularly round the papilla. Bruns has shown their exact distribution (See Figs. 54 and 55). As in ruminants and in the cat the vessels of the dog's retina irrigate the whole of the internal wall of the eyeball.

Cat. In consequence of the mobility of the pupil in this animal it is absolutely necessary to instil a solution of a mydriatic into the eye before trying to examine the fundus. [If, however, it is carried out in a shaded or dark room, and an electrically illuminated ophthalmoscope be used, there is no need for mydriatic, even in an albino].

The *tapetum lucidum* shows a rich colouring, yellow around the papilla, green at the periphery—a green dotting is fairly often met with. The limit between the two tapeta is diffuse and formed by a border of indigo blue. This passes into the tapetum nigrum which is intensely black and reflects no light, making it difficult to follow the vessels. [In the Siamese cat, the colouring and its distribution resembles that encountered in many chocolate-coloured Pomeranians, dachshunds, etc.].

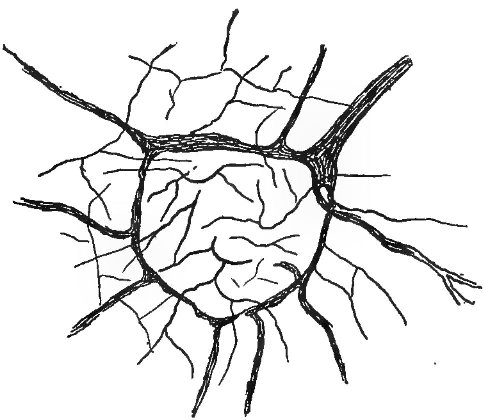


Fig. 55. Vessels of the papilla of a dog. (After Bruns).

The *papilla* situated in the tapetum lucidum is almost circular, grey or salmon coloured, bordered with a shaded black line. An indigo-blue ring encircles it. The veins of the

retina can be distinguished from the arteries, the disposition of which being almost the same as in the dog. They differ, however, in that they encroach but little on the optic disc (Plate III, Fig. 2).

Elephant. The Indian as well as the African elephant has a yellow ochreous or golden fundus, closely streaked all over with irregular or bent short linear markings. The papilla is circular and of a French grey colour. The vessels are few in number, very small in outline, and radiate from the disc in a somewhat similar manner to those in the horse.

Pig. The fundus oculi of the pig is of a light chocolate red colour, with numerous, somewhat opaque nerve fibres regularly radiating from the papilla. There is no tapetum lucidum. The arteries and veins are very large and cannot be distinguished from one another].

Congenital peculiarities in the appearance of the fundus. These include the *opaque nerve fibres* and congenital depigmentations of the retina and choroid.

Opaque nerve, medullated nerve or myeline fibres. The moment the optic fibres spread out to form the retina they lose their myeline sheath and thus form a perfectly transparent membrane for the luminous rays which go to form impressions on the layer of rods and cones.

The retina is for this reason invisible with an ophthalmoscope, and were it not for its blood vessels it might be doubted that a membrane (the most sensitive of the eye) lines the internal face of the choroid. But when the myeline sheath—a fatty substance surrounding the axis cylinder—persists, the fibres of the retina become visible in the form of whitish striæ. These are also known as double contoured fibres. They are met with in 60 per cent. of horses (Nicolas and Fromaget, Boitelle), are more or less abundant and close together, according to the eye, and consequently form whitish veils of variable thickness, situated as a rule on the circumference of the papilla and not extending further from the centre than do the blood vessels. Sometimes they are sufficiently far apart to allow the subjacent membranes to be seen as if through a thin white veil; in other cases they are more abundant and form an opaque covering; the purplish retinal

vessels are interrupted, the border of the papilla is diffuse and striated. Lastly, the membrane is (exceptionally) absolutely white, milky, and quite opaque. The vessels of the retina are not so visible; the choroidal and scleral rings are clearly outlined. In this case these myeline or opaque nerve fibres occupy a more limited space, and form finely striated bundles—tufts ending like locks of white hair. They are usually found on the infero-lateral aspect of the papilla (Plate IV, Fig. 1).

Some observers, only considering the most typical of these cases, have wrongly, in our opinion, denied the great frequency with which these opaque nerve or myeline fibres are found in the retina of the horse. Their presence has been recognised in the [dark-haired races of man, simian apes], ox, dog (Kölliker, Müller), bear (Müller), pigeon and fish (Kölliker) The existence of these opaque nerve or myeline fibres is the rule in the Leporidæ, [and in some of the marsupials, notably the Perameles lagotis], in which they are spread out in a horizontal direction.

Von Hippel's investigations in the rabbit, corroborated by those of Ambronn and Held, have shown that they are only developed after the eye is opened to the light.

Spots of depigmentation of the Retina of congenital origin. These are irregular and have their bases formed by the choroid; they have a colouration varying with their situation —green, blue or yellowish on the supero-lateral aspect of the papilla, and reddish below. If in an enucleated eye after lifting up the retina, which always leaves its pigment on the surface of the choroid, the finger is passed over the surface of the tapetum nigrum a spot is left like those described above.

Disseminate circular patches of choroiditis all the same size and sharply limited, are very different; their bases are scarred and sometimes spotted with pigment. (*See* Choroiditis and Plate VI.)

Congenital depigmentation of the choroid. Absence of choroidal pigment only causes a modification in the ophthalmoscopic appearance if there is a corresponding defect of the more superficial layers—the pigmentary layer of

the retina in the tapetum nigrum, and the fundamental layer in the tapetum lucidum. The pigment of the choroid fairly uniformly spread throughout the vascular layer, as can be seen in microscopic sections of the choroid, may disappear in the vicinity of the large vessels although remaining more or less abundant in the intervals between them. Under these conditions, more or less wide spots can be seen usually in the neighbourhood of the papilla, their borders being clearly marked and on the bottom of which a vascular network is traced. The vessels, very well shown, measure 2–3 mm. by the erect image (*See* Plate IV, Fig. 2, and Plate IX, Fig. 1).

The vessels of the retina run over the surface of these spots and cross the vessels of the choroid.

Limited congenital absence of pigment seems to have no ill effect on the sight.

Eye Shades.

To avoid repetition the methods of applying dressings to the eyes are briefly described below.

1. **Suture of the Eyelids.** This is one of the best methods of protecting certain operation wounds from infection and of applying gentle pressure. Two or three sutures

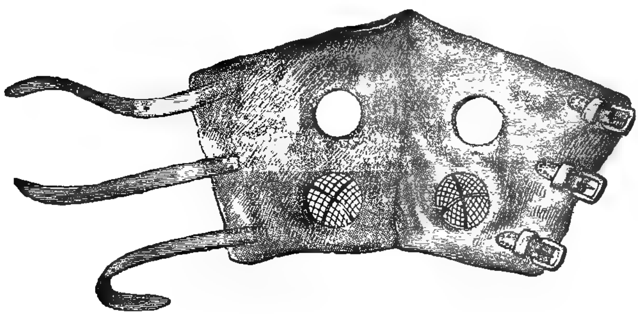


Fig. 56. Brusasco's eye shade (Cadiot and Almy).

in dogs, three or four in horses, are passed, bringing together the free edges of the lids, allowing drainage at the internal angle for tears and conjunctival secretions. Such sutures may be left in place five to six days according to the case.

An ophthalmic hood, Pécus' and Brusasco's apparatus. The former is used for large animals and particularly horses, Brusasco's protector chiefly for dogs. The ophthalmic hood is a mask similar to that used for casting animals, the eyeholes of which are moveable and secured by two or three small straps. To apply a dressing to cover the eye fill the eyeholes with cotton wool and apply them to the closed eyelids. In this manner a dry dressing or moist compress may be kept on the part.

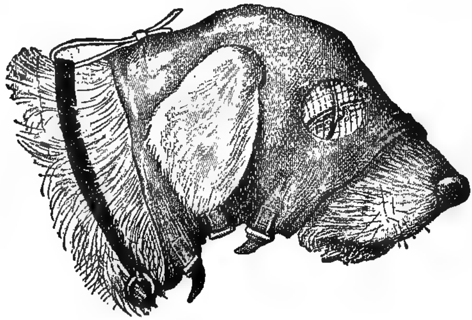
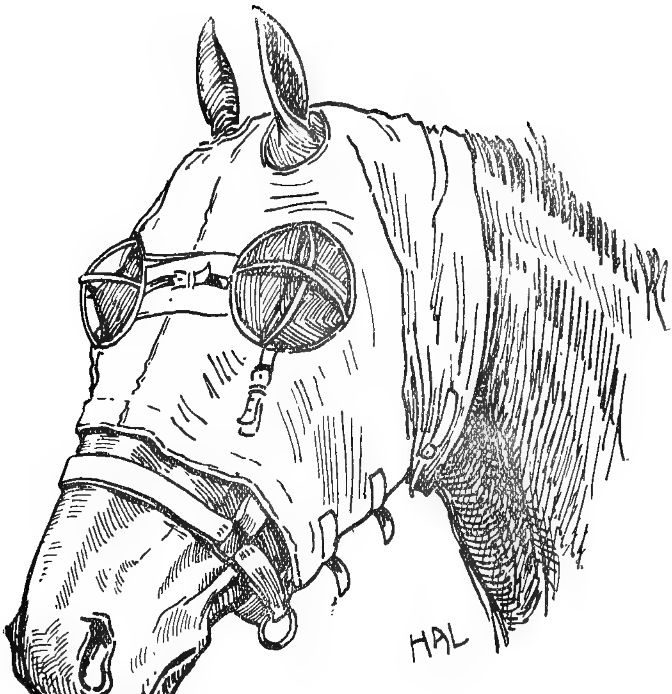


Fig. 57. The same in position.

The ophthalmic hood advantageously replaces Bourgelat's bandages and Brogniez' or Brusasco's protectors (Figs.).

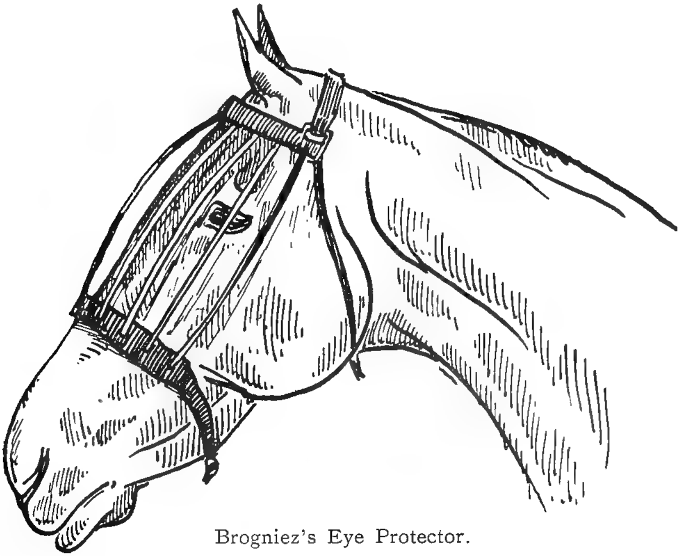
Brusasco's protector is practically the same apparatus applied to the dog (Fig. 56 and 57). It can be made in an hour from a square piece of linen, replacing the straps by tapes. In place of the metal trellis over the eyes simple slits in the cloth may be made and kept closed by small strings. The dressing is applied as before, and the fastenings tied. Cadiot and Almy have rarely found animals which will keep on a simple bandage; these bandages are difficult to maintain on the quietest patients.

Further, to prevent the possibility of the animal rubbing the eye, horses should be placed on pillar reins or tied in some similar manner. Dogs may if necessary have the fore



Brusasco's Eye Protector.

paws tied together. [In the translator's experience, allaying irritation by cocaine or some similarly acting agent and keeping the animal in a dark stable or kennel is all that is necessary. Some practitioners in England, however, use on



Brogniez's Eye Protector.

dogs an aluminium Elizabethan collar or ruffle, or a cane or wire cradle on the neck; others confine the animal in a narrow box, with a hole in the front for his head to project from, or the body and limbs in a small bag so that their paws cannot reach their eyes; others, again, apply socks to the feet so that the eyes are not injured by the claws].

CHAPTER V

THE CONJUNCTIVA.

Anatomy and Physiology.

The conjunctiva is a mucous membrane which covers the internal surface of the eyelids and the anterior segment of the eyeball. Passing from the eyelids to the eyeball, or *vice versa*, it thus forms a sac—open in front and closed behind; its two walls glide on one another when the eye or eyelids are moved. Three parts are distinguished. The *palpebral conjunctiva* intimately connected with the lids and continuous with the skin at their free edges. The *bulbar conjunctiva* lightly bound to the sclerotic by the episcleral tissue and prolonged on to the cornea to form its epithelial layer. The third is the *fornix* or *saccular portion*, uniting the two previous parts, and formed into folds to allow of the movements of the eyeball. These conjunctival culs-de-sac which, together represent a furrow enveloping the whole anterior hemisphere of the globe, are doubled in behind the edge of the membrana nictitans. They are deeper above and on the inner side than below and on the outer side. In the horse they are 3 cms. from the margin of the cornea above, and 2½ cms. inside, below, and outside.

[That portion of the conjunctiva which overlaps the margin of the cornea is known as the *corneal*, *sclero-corneal* or *conjunctival limbus*].

In the nasal angle of the eye the conjunctiva forms two folds, one covers the two faces of the cartilage of the third eyelid, the other helps to form a covering for the caruncula lacrimalis.

The conjunctiva is nearly always pigmented in the neighbourhood of the corneal limbus in the horse [and in the dog]; when pigment is absent the eye is said to show its "white" or to be "hooped" (œil cerclé).

Structure. The conjunctiva is made up of a *chorion* and an *epithelium*. The *chorion*, formed of a connective tissue stroma with an abundance of elastic fibres in the horse, dog, ox, and cat contains in its meshes lymphatic follicles and glands. The *lymphatic follicles*, which are completely closed, are globular or elongated and superficially situated. In man true lymphatic follicles do not exist, but there is an infiltration of lymphatic cells. In animals, they are more or less numerous according to the species, and in the same animal their number varies with the age, the part examined, and even the time of the year. Morano has found them to be more developed in autumn and summer than in spring in sheep; this, he explains, by the animal obtaining better nourishment in the finer weather. In the ox they are very numerous, and are known as the *plaques of Bruch*. In the horse they are arranged around the cornea; in the dog they are more developed in the internal angle of the eye and in the bulbar portion. In all they are particularly abundant on the inner face of the third eyelid and in the inferior cul-de-sac, where they resemble the disposition of Peyer's glands.

The *glands* of the conjunctiva are of several kinds:—(a) *Acinous glands* (Krause), few in number, two or three to each eyelid, and situated near the external commissure; they have been considered as accessory lacrimal glands; (b) *Utricular glands of Manz*, found close to the circumference of the cornea in animals; (c) *Glands of the membrana nictitans*, described by Peters in the ox, pig and rabbit, and in section resembling the lacrimal gland; (d) the tubulo-alveolar *gland of Harder* is situated on the internal face of the third eyelid, on to which it opens by one or more openings [and occurring in those amphibia, reptiles, birds and mammals, and it is said even in those sharks (?) having a third eyelid]. It seems to be connected in its development with that of the membrana nictitans. Very large in birds, in which it exceeds the lacrimal gland, it is wanting, as a rule, in man and monkeys, in which the third is reduced to a minimum [and in whom this rudimentary organ is known as the *plica semilunaris*]. It is fairly

large in the dog [and cat, and very large in the ox and sheep]. In the horse it is reduced to some scattered granulations (Foltz) [situated a little below the middle third of the outer face of the cartilage, which forms the major part of the membrana nictitans, and to which it appears almost intimately blended]. Its thick greasy looking secretion appears to protect the animal's eyes from dust when lowered towards the ground (Krause).

The *epithelium* varies according to its situation; it is cylindrical on the inner face of the lids and in the cul-de-sac; near the free border of the lids it becomes pavemental, and also on the bulbar portion where it is continuous without transition with that of the cornea. The *arteries* come from the palpebral and anastomose with the anterior ciliary, and the *veins* run into the facial and the ophthalmic. The *nerves* come from the fifth cranial pair.

Examination of the conjunctiva and its culs-de-sac. This can be done in two ways. *Naked eye* examination is possible and easy in the dog and cat. By drawing the upper lid upwards by means of the thumb placed on the skin near the palpebral edge and the lower lid downwards in the same way almost the whole of the conjunctiva can be exposed at once in the dog and cat.

In the horse and in ruminants only the bulbar or circum-corneal portion can be seen. To examine the rest a *digital exploration* has to be made; this is especially useful if a foreign body is suspected (Hamor). The index finger—the nail of which has been carefully pared—is directly introduced between the upper eyelid and the eye as far as the bottom of the *cul-de-sac* and the tip of the finger (which is most sensitive) is turned towards the part to be examined. In the superior part the finger is made to glide backwards and forwards under and over the membrana nictitans, and below in the same way till the whole of the walls and depths of the conjunctival sac have been recognised. The operation presents no difficulty if the head is held as still as possible and lowered a little to facilitate the movements of the hand; it is also not dangerous to the eye.

Inflammation of the Conjunctiva. From its great vascularity, its richness in lymphatic cells, and its reflex sensibility, the conjunctiva is often the seat of inflammatory phenomena assuming different clinical forms.

Catarrhal conjunctivitis. This form is especially characterised by a change in the colour of the mucous membrane and a mucous or slightly muco-purulent discharge. Vascular injection forming a close but well defined network gives to the membrane a pink or abnormally red colouration, which is sometimes accompanied by a yellow tinge when there is interstitial infiltration as well.

The greyish white mucous secretion, which forms small clots or strings, becomes yellowish and more liquid when it contains an appreciable quantity of pus. In slight cases the strings and specks cling to the cornea and are displaced by each movement of the eyelids—thus distinguishing them from opacities. When it is more intense the secretion adheres to the edges of the lids and accumulates in the internal angle of the eye when it interferes with the flow of tears. The palpebral edges, besides being damp and dirty, may also be slightly tumefied. A slight degree of photophobia, rapid movements of the lids, as well as their complete closure at the least attempt at an examination show the abnormal sensitiveness of the eye. Catarrhal conjunctivitis is as a rule benign, but it may persist for some time, some cases being very tenacious.

Etiology. It cannot be denied that every mechanical, chemical, or atmospheric influence plays a part in the development of the catarrh. Dust and sand raised by the wind [scales emitted with smoke from locomotives], slight blows from leaves or twigs, [glumes of grass, hayseeds, oat-flights], chaff, smoke, irritant gases such as ammonia given off in badly built stables and sheds, intense cold, currents of cold air, too bright light, especially that reflected from snow [snow blindness], are the causes commonly given for catarrhal conjunctivitis.

Infection. If the fact that any form of conjunctivitis is inoculable be considered—a fact long since proved by von Gräfe, and corroborated by bacteriological experiments actually undertaken on men, which tends to prove that each form of conjunctivitis has its own specific agent—then one is led to believe that the preceding causes only play an occasional *rôle*, leaving the determining action to some form of living micro-organism.

Epidemics of conjunctivitis observed in man and animals help to support this theory of its etiology. In the German Army several repeated outbreaks of catarrhal conjunctivitis in horses have been seen (Müller), but their determining cause has not been discovered. Nicolas observed a small enzoöty of conjunctivitis which could be considered as experimental, as it occurred in about thirty animals in which inoculation was accidental. In order to make an ophthalmoscopic examination of a number of young animals an instillation of atropine was made previously. The following day all the animals so treated showed symptoms of fairly severe catarrhal conjunctivitis, and as he had never seen catarrh due to atropine (this being very rare), it could not be suspected in this case. The solution of atropine, which might have been contaminated, was thrown away, and the dropping glass was boiled. Further instillations caused no reactional phenomena.

The most common cause in man is the bacillus of Weeks and the diplococcus of Morax, neither of which is inoculable to animals. Inoculation of the pneumonococcus into the eyes of rabbits by subconjunctival injection or scarification was twice successfully performed by Gasparini in 1893. A slight conjunctivitis was observed which lasted about ten days, and the secretions from which contained the encapsuled diplococcus of Fränkel.

Whether major organic infections, which in animals often betray themselves, even in the beginning, by a catarrh of the conjunctival membranes must be assumed to be due to endogenous infection by metastasis of the organism in question, or to the action of the products of their disintegration

is a difficult point to decide. Nocard does not accept the conclusions resulting from the researches of an anonymous author, who tried to prove that the bacterial examination of conjunctival secretions could be used in the diagnosis of the infective disease, of which the eye affection was a symptom. —(*Bulletin S.C. Vét.* 1900).

In any case this catarrh is met with in different forms of infection from the pasteurelloses, (influenza), purpura hæmorrhagica or petechial fever, dourine (Schneider and Buffard), in the horse; malignant catarrh and rinderpest in the ox (Arloing), [catarrhal fever in sheep]; erysipelas and swine fever in pigs; distemper and diabetes in dogs (Sendrail and Lafon).

Besides these conjunctival infections, on the nature of which laboratory researches should throw some light, there may be other causes. *Chemical conjunctivitis*, which is met with in man, has also been recognised in veterinary practice. By means of small instillations of infusion of jequirity Römer has experimentally caused lesions of catarrhal conjunctivitis, hyperæmia extending to superficial or even deep necrosis with infiltration and subconjunctival hæmorrhage. Lime acts in the same way, and Möller relates that in a Prussian regiment an outbreak of catarrhal conjunctivitis was greatly extended after whitewashing the walls of the stables, and that the disease died out when the whitewash was removed. [The internal administration of arsenic, iodide of potassium either alone or in conjunction with the external application of mercurial preparations to the eyes, and certain other medicinal agents will also cause in susceptible animals catarrhal conjunctivitis].

Certain irritant collyria too often instilled, for example, silver nitrate may cause catarrh which may also appear in certain subjects intolerant of eserine and atropine. Bidault's case, in a horse, of conjunctivitis due to instillations of atropine is the only one, as far as the present author knows, which has ever been reported as occurring in animals. [It is, however, somewhat frequent in the cat and dog. Mallein

and tuberculin applied to the conjunctiva as a test for glanders and tuberculosis respectively generally sets up a catarrhal conjunctivitis if these infections are in the system. It is also sometimes seen in the tuberculous dog after the sub-subcutaneous injection of tuberculin].

As aniline dyes have for some time past been used in medicines as therapeutic agents it should be remembered that they are irritating to the eye. It is in this category of chemical conjunctivitis that the ophthalmia caused by constant exposure to light reflected from snow, which may be due to the ultraviolet rays of reflected light must be placed. In this case the inflammation is shown by œdema of the eyelids, hyperæmia, and a mucous secretion in man [and in animals (Walley)]. It sometimes produces corneal ulcers (Gardner), slight opacities, and even iritis. The pupil is usually contracted. In our animals, this form has been particularly noticed in cattle in Russia, where its extension to thousands of animals attracted the attention of the government. Agriculturalists (according to *The Optician* of 1891), under the advice of Dr. Vérincourt of the Department of Agriculture, have accustomed their cattle to wear blue spectacles to avoid this affection. The sight of a thousand head of cattle gravely wearing spectacles must, needless to say, be a curious one.

The *mechanical action* of foreign bodies, inert or living (filaria), lodged in the conjunctival culs-de-sac, or under the membrana nictitans, also produces this form of conjunctivitis. [Leese has encountered in the camel in India a filaria, identified by Railliet as the *Thelazia Leesi*; it is found in the conjunctival sacs, where it sometimes sets up conjunctivitis.]* Lang and Noc, however, have seen the filaria of the fowl (*F. Mansoni* Cobbold) very widespread in New Caledonia, under the third eyelids of poultry, only causing a slight pruritus. *Obstruction of the lacrimal canal* by dust is not rare in troop horses in the summer time, especially on manœuvres, and it is always accompanied by a catarrhal conjunctivitis.

* *Veterinary Record*, Vol. XXIII., 1910-11, p. 139.

Treatment. Attention should first be directed to removing the cause, if possible, by frequent disinfection of eye droppers, search for foreign bodies in the culs-de-sac and under the membrana nictitans, and removing obstructions from the lacrimal canals. [Leese uses, to remove filariæ from the conjunctival sac of the camel, a weak solution of boracic acid, injected by a syringe after the eyelids and haw have been raised]. Conjunctival secretions are removed by frequent washings with warm boracic lotions, potassium permanganate 1 in 4,000, or corrosive sublimate of the same strength applied with pledgets of sterile cotton wool, or by means of a feeble stream from a syringe; a curved canula like that of Drs. Kalt and Lagrange which can be inserted between the lids and the eyeball without fear of injury may be used. Then twice daily a few drops of any of the following collyria may be instilled into the eye:—1-2½% solution of sulphate of zinc; 1-2% tannic acid; [1-500 chinosol]; 10-20% protargol [which Macqueen considers to be too strong, 2–5 °/₀ being sufficient]; prepared in each case with boiled distilled water. If the affection is contagious or very tenacious in character, these may be replaced by .5% nitrate, one or two drops instilled once daily only.

The necessary prophylactic measures such as isolation, disinfection, etc., to prevent the spread of the disease, must be taken.

Acute Purulent Conjunctivitis. A purulent secretion being characteristic of every case of conjunctivitis this type only exists from the point of view of classification because the inflammatory reaction is more intense, and the secretion from its colour, consistence, and quantity suggests the idea of purulence more than in the preceding cases.

The conjunctiva assumes a uniform red tinge. Its infiltration is marked and is often accompanied by chemosis, [especially in the cat and dog]. The thick, and sometimes even caseous secretion may fasten the eyelids together, as happens in birds, [cats and dogs]; being very irritant it easily

causes inflammation of the cornea with ulceration. The eyelids are swollen, more or less closed, covered with crusts of dry pus sticking to the lashes, and cause them to fall out (Ménard, Delmer). Purulent conjunctivitis is often accompanied by pain, causing movements of the animal's head and frequent protrusions of the membrana nictitans, with scratching at the eye in dogs and birds. General symptoms include dulness, loss of appetite, and emaciation. In birds it may terminate in death.

Etiology. Especially common in ruminants, [cats], and dogs, it is not rare in poultry, and it is also seen in horses. It often assumes an enzoötic or epizoötic character. In a single year Schischkowski treated 600 head of cattle for this affection. Delmer saw a herd of 22 goats affected. Guilmot observed a large outbreak in dogs in 1853 and 1856, and Müller reports that in 1883 blenorrhœa of the eye raged with great violence in Berlin and its suburbs. Emmerez and Mégnin, and Marotel and Carrougeau, have studied enzoötics of purulent ophthalmia in fowls; Saint-Yves Ménard saw the disease affecting 14 horses at the Jardins d'Acclimatation.

It is more than probable that its spread is due to contagion, but in some cases this cannot be proved. Delmer transmitted the affection by the deposition of pus taken from the eyes of affected goats on the conjunctiva of healthy goats, but the inoculation did not succeed in dogs, sheep, pigs, oxen, or rabbits. The inoculated goats rapidly communicated the disease to healthy animals placed with them, and even at some distance.

In purulent ophthalmia in birds—usually verminous ophthalmia—contagion is certain, and takes place as follows: In order to get rid of the troublesome secretions, and of the worms when these are the cause of the affection, which interfere with vision and make respiration difficult by obstructing the nasal opening, the bird shakes its head and communicates the affection to the other eye, at the same time transmitting it to its neighbours. The affection also produces a secondary inflammation in the upper air passages. In fowls

and chickens in Mauritius (Emmerez and Mégnin), in the poultry of Annam (studied by Marotel and Carrougeau), the affection was due to a Spiroptera (*S. Emmerezii* Mégnin, which, according to the researches of Marotel and Carrougeau, is the same as the *S. Mansoni* Cobbold). These are very thin white worms found in the conjunctival culs-de-sac, and especially under the membrana nictitans, to which situation they quickly move if the lid be raised. They may pass into the nasal cavities and sinuses, but never penetrate the anterior chamber of the eye.

Comparing the assertions of the four authors above-mentioned with the somewhat different reports of Lang and Noc, as they all seem to agree that the parasite found may be the same—the *Filaria* or *Spiroptera Mansoni* Cobbold—it may be asked whether the parasite is the primary cause of the purulent conjunctivitis, or whether it only carries an infective agent causing suppuration, or even whether the disease is not occasioned by the irritation which it provokes, or by the scratching with the claws leading to purulent infection ?

Recent observations by Fugita in the Island of Formosa and Penning in the Dutch East Indies show that, in spite of a large number (200) of filariæ (*Oxyspirura Mansoni*) measuring from 15 to 20 mm. in length and 0·3 to 0·4 mm. in diameter, which may be met with in the conjunctival sac of fowls, the conjunctiva is free from inflammation. A little granular roughness, with a corresponding slight epithelial thickening, may be shown, but Fugita has seen this granular condition in the conjunctivæ of healthy fowls, showing no filaria. (*Archiv f. vergl. Ophthalmologie*, Band I., No, 4, p. 422).

Although the development of purulent conjunctivitis in other animals would suggest some kind of *infection*, it is not in the least known what the agent is or by what means it gains access to the eye. A fairly virulent streptococcus injected under the conjunctiva of *rabbits* causes a generalised inflammation with a well marked purulent secretion (Moraux). In Delmer's observations on goats, the author succeeded in isolating a staphylococcus, but cultures of the organism did

not reproduce the affection. [The causal organism, however, is ultravisible.]

The older French veterinary authors mention blennorrhagic ophthalmia, and Bayer, Möller and Vachetta still use the term. Etymologically, this means ophthalmia with discharge of pus, but in man it has another more specific meaning which leads to ambiguity. It suggests that the ocular suppuration is due to infection by the pus of blennorrhagia or gonorrhœa. It may be mentioned that this grave affection usually occurs in adults from lack of proper precautions as to cleanliness, allowing the fingers soiled with blennorrhagic pus to be carried to the eye, and in newly-born infants when the mother is, at the time of parturition, suffering from a vaginal discharge. In practice, this ophthalmia goes by the name of gonococcic or gonorrhœal ophthalmia, being caused by the gonococcus of Niesser. Now the gonococcus of Niesser has never been found in the conjunctival secretions of animals, and it is not inoculable to them?

But it seems reasonable to suppose that contact with the preputial discharge so commonly seen in dogs and in the genital passages of bitches about the time of parturition may be the cause of a conjunctival blennorrhœa? And that this actually happens is stated by Hönisch and Roloff, quoted by Hoffmann, who have observed enzoötics of blennorrhœa in newly-born animals, first in foals and then in lambs; [it has also been seen in newly-born lambs by Rankin]; *and quite recently (1905) "Omega," † an anonymous writer, recorded an affection of new born kittens, the mother of which was suffering from vaginitis; the disease spread in the neighbourhood and appeared in the kittens of other litters.

[This acute purulent conjunctivitis of the new-born (*Ophthalmia neonatorum*) is a very common disease in the kitten. It is also seen in the puppy, but not in such frequency as in the former animal. It may manifest itself *before* or very

* *The Veterinary Record*, vol. xvii., 1904-5, p. 777.

† *Idem*, p. 804.

soon after the eyelids have separated. Some she-cats never bear young free from this complaint, which is enzoötic where several cats are kept, and may persist for years unless the disease is stamped out. The mother-cat usually shows some, even though slight, catarrhal symptoms. If it should occur before the eyes are open it nearly always destroys the sight from profound lesions of the eye. Infection from the vagina is out of the question, as the disease may occur before the eyes are open. Chronic vaginal or uterine catarrh nearly always ends in sterility, but the mother of affected kittens frequently gives birth to several litters which become affected in their turn. In Gray's opinion the great majority of cases of acute purulent conjunctivitis in the cat and dog are a special manifestation of distemper. It is very common in homes for stray cats, where it often recurs, especially if the animals are kept for a lengthy period. During certain periods having more or less lengthy intervals the cat and dog suffer from a type of distemper, principally characterised by intense chemosis, and everted eyelids showing a swollen conjunctival mucous membrane, which secretes a thick creamy or yellowish purulent material. This is generally termed the pink-eye type of distemper.]

These facts are not remarkable if it be considered that the pus of vaginitis in the human female, which produces blennorrhagia in infants, sometimes contains staphylococci, streptococci, pneumococci (Morax, Parinaud), or even the bacillus coli communis (Bietti). On the other hand, having noticed that among a number of hounds suffering from purulent conjunctivitis, a number showed signs of balano-urethritis or vaginitis, Guilmot attributed the suppuration of the urino-genitary passages to the ocular affection which, from a symptomatic point of view, was absolutely comparable to the blennorrhagic or gonorrhœal ophthalmia of man. He reproduced the disease experimentally by placing the blennorrhagic muco-pus on the conjunctivæ of nine dogs, keeping it in place for nine hours by means of a compress. The conjunctivitis thus developed caused infection of the cornea

and corneal ulcers, as in the spontaneous affection which sometimes ends in perforation. Probably only the characteristic discharge of distemper was used by Guilmot.

Möller and Cadiot repeated these inoculations, but without succeeding in producing conjunctivitis. Nicolas has had no success in spite of many varied experiments. He first of all used adult dogs inoculated by scarifications or submucous punctures with pus taken from the urethra [? sheath] of other dogs. He then repeated the experiments on young puppies as soon as their eyes were open.

Lastly, a tube of broth was inoculated, and after several days' culture an attempt at inoculation was made by injecting up to 1 c.c. of the culture under the conjunctiva, but without success. Nicolas has not had any successful result from the inoculation of pus on to the urethrae of young dogs from the eyes or from cultures. His examinations of pus from the urethra have in every case shown the presence of a cocco-bacillus having all the reactions of the bacillus coli. Sometimes a few colonies of the staphylococcus albus were found. As a sporadic condition, purulent conjunctivitis is met with fairly often in distemper, and sometimes also in strangles.

Course. Experimental infection of goats by Delmer developed the disease after a short period—24 to 48 hours. The malady ran its full course in from 4 to 30 days, varying according to the case. Blennorrhœa in newly born kittens, described by "Omega," develops from the first to the twenty-first day after birth, but it is not often recognised till the eighth or ninth day, when the eyes are opened. [It may, however, occur weeks after weaning]. In these cases the pus has accomplished its destructive work, and will have caused ulceration and perforation of the cornea. According to Guilmot's observations the disease disappears about the tenth to the twentieth day.

Prognosis is always very grave and should be guarded, terminations being very variable; resolution, ulceration of the cornea, perforation and panophthalmitis, blindness and sometimes death. Blindness is the commonest sequel and prevents

the animal getting its food; but in *birds* there is another complication in which the parasites causing the verminous ophthalmia may reach the nasal cavities, sinuses, and even the air sacs.

Treatment. This consists in precautions with regard to isolation and disinfection to prevent the spread of the infection.

To check the conjunctival secretion, the same measures as those adopted for the catarrhal form may be used. Nitrate of silver may be employed in moderation if not applied too many times daily. In cases in which no corneal ulcer exists it is well to apply the silver solution on a camel hair brush, or pledget of cotton wool by means of forceps, so as to limit its zone of action. Delmer has not obtained good results with this agent, which in 2 per cent. solution he found to increase the secretion; he leaves off using it after the fourth day and replaces it by simple irrigations with boracic lotion. In man Legrange recommends the use of protargol (4 to 8 per cent.) in purulent conjunctivitis accompanied by corneal lesions. [Chinosol 1: 500 or even stronger is a useful agent.]

Verminous ophthalmia suggests the removal of the worms as the first step; sodii bicarb. solution instilled several times daily is said to expel the parasites (Emmerez and Mégnin). But to rid the eye of the worms it is necessary to remove them completely with a piece of linen or fine forceps, after having everted the lids and raised the membrana nictitans.

In addition to local treatment, Guilmot gives purgatives and balsam of copaiba internally.

Chronic Purulent Conjunctivitis.

[Besides the purulent conjunctivitis just described, there exists in the dog a chronic form, which is of especial interest as it is obstinate to treatment, liable to recur when arrested for a time, and may persist throughout the animal's life. It is generally seen in animals kept under bad hygienic conditions or suffering from an eczematous diathesis.

It may or may not be associated with granulations, and is

often a sequel to distemper. It is very liable to become complicated with a vascular condition of the cornea, which may eventually undergo pigmentary degeneration. The surface of the cornea loses its polish and becomes roughened by the loss of epithelium.

The conjunctival vessels are injected, and the membrane is rough and discharges a purulent material which clings about the eyelids. It is, however, not so profuse, nor is the injection so intense, as in acute purulent conjunctivitis. When the cornea undergoes chronic changes the animal is more or less blind.

Treatment. When the disease confines itself to the conjunctiva it may be advisable to evert the eyelids and to paint the membrane with a 10 or 20 per cent. solution of nitrate of silver, taking care that the whole surface is thoroughly dressed, that none of the solution reaches the cornea, and that before the eyelids are allowed to resume their natural position the conjunctival sac is washed out with a warm solution of common salt to neutralise the free nitrate of silver and to wash away the débris. For the same purpose as the silver salt, a crystal of sulphate of copper may be rubbed on the conjunctival membrane.

If this method is not successful, and should there be any vascularity of the cornea, a collyrium composed of 1 part of biniodide of mercury, 10 parts of iodide of potassium and 5000 parts of distilled water, to which atropine is added, should be instilled into the conjunctival sac three times a day.

It is possible as time goes on that the bacteriology of this complaint may be determined, and ultimately a vaccine or serum introduced for its cure].

Conjunctivitis with False Membranes.—As these false membranes may be produced by various causes they are not characterised by any special etiology; on this account the term diphtheritic conjunctivitis has been avoided, though it is generally used by other authors. From a symptomatic point of view this form of conjunctivitis is characterised by the formation of a membranous exudate adhering to the con-

junctival mucous membrane. It is most frequently met with in birds, but may also be seen in cattle, goats, and dogs (Lafosse, of Toulouse). As a rule, in the horse it occurs under certain fixed conditions which will be mentioned later.

Birds. The false membrane covers the conjunctiva, especially the palpebral portion, but it may fill the culs-de-sac and cover the anterior part of the eyeball like an elastic hood; it is adherent, resistant, and yellowish or brown in colour (Larcher). According to its thickness the eyelids are raised up, sometimes considerably swollen, and more or less rigid and immovable. It is sometimes accompanied by a thick, yellowish, purulent looking secretion which runs down and soils the eyelids, beak, and upper air passages and, from the animal shaking it head, may be found all over the body. In other cases the discharge almost resembles serum. Under the false membrane the conjunctiva becomes ulcerated as well as the cornea, and necrosis may cause perforation of the anterior chamber. In still other cases the pressure of the exudate causes the cornea to become flattened and opaque, the eye is pressed back in the orbit and atrophies. Pseudomembranous inflammation of the conjunctiva co-exists, as a rule, with similar affections of the nasal and pharyngo-laryngeal mucous membranes. General symptoms pointing to intoxication from absorption of the products of the organism are almost always seen: depression, a staring condition of the feathers, loss of appetite and wasting.

Etiology. In a film made from one of these false membranes the field is seen to be very rich in micro-organisms: bacteria, micrococci, streptococci, bacilli, moulds, protozoa. Rivolta (1873), and later Perroncito, Brusasco, Trinchera, Bollinger, and Siedamgrotzky found the protozoa to play a great part in the causation of the disease, especially sporozoa and gregarines; however, Guérin of the Pasteur Institute at Lille, who in 1903 studied this form of conjunctivitis in chickens and pigeons, only attributes the presence of Protozoa to the birds scratching at their eyes. On the other hand, however, in birds, as in man, some bacteriologists

have found the Klebs-Löffler bacillus and have accused it of being the cause of an avian diphtheria; but Guérin puts forward the fact that the organism is found on healthy mucous membranes as a proof that it is not the cause of the diphtheritic deposit and he does not attribute any pathogenic action to it, though not denying that it may be found. His studies pursued in such a constantly infected area as the poultry yards of the Northern Departments of France where game cocks are raised on a large scale, brought to his notice the fact that in spite of the near proximity of the animals to men, necessitated by the training of the birds, there is no record of infection from one to the other. Further, he has isolated a pasteurella with which he has reproduced the disease experimentally, and this he considers to be the specific cause of avian diphtheria. After inoculation of the inferior palpebral conjunctiva the eye became half closed and there was a flow of tears followed by œdema which, from the influx of a great number of leucocytes, gave rise to a yellowish white false membrane. [Bordet has, however, isolated and cultivated on a special medium a very small micro-organism, about one-fifth of a micron in size, which is thought by some to be the cause of avian diphtheria. Others believe it is due to an invisible virus which appears to be common to epitheliosis and to diphtheria].*

Infection takes place *via* the excreta, which always contain the pasteurella in fairly large numbers. With regard to the ocular form of diphtheria which so commonly affects poultry, it is caused by the habit of the birds scratching at their eyes with soiled claws. Other organisms may also cause the formation of false membranes on the mucous membrane: the bacillus coli, pneumococci, streptococci in man, the necrosis bacillus in fowls (Cuillé) and almost all animals. In ducks suffering from membranous conjunctivitis (to the exclusion of other farmyard birds) Kampmann, Hirschbrusch, and Lange found pseudo-diphtheritic bacilli. Many other cases of

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**Journ. Comp. Path. and Therap.* Vol. xxi. 1908, p. 90, and *Bulletin de l'Institut Pasteur*, 1907, p. 992.

membranous conjunctivitis have been reported, especially in Germany, without the exact cause being ascertained.

Prognosis. As in purulent conjunctivitis, this affection is a grave one on account of its contagious characters and the economic losses which it entails: wasting from loss of appetite and pain, arrest of growth in young birds, falling off in the supply of eggs, and a heavy mortality (Rabus, Ammerschläger).

Treatment. Researches undertaken by Guérin with the object of finding a protective serum like that of human diphtheria capable of arresting the course of the disease when it manifests itself, and of softening and detaching the false membranes, were unsuccessful. He then turned his attention to preventive methods, and found an efficacious preventive vaccine, which is supplied by the Pasteur Institute. The vaccination consists of two inoculations with an interval of twelve days, the second vaccine being of greater virulence than the first. The method can only be used on young birds undoubtedly free from the disease, and the most favourable age is found to be at from 10 to 15 days after hatching. [Some authorities assert they have had success with antidiphtheric serum prepared for man].

The treatment of this recognised disease needs the usual prophylactic measures used in such cases: isolation of healthy birds from affected, and disinfection of poultry houses, yards, aviaries, pigeon lofts, etc. The eyes may be bathed with antiseptic solutions—potassium permanganate, corrosive sublimate 1 : 4000 [or a solution (10 %) of hyposulphite of soda (Macqueen)]. The false membranes must be carefully raised, the mucous surfaces exposed, bathed with any of these solutions, and swabbed with oil of turpentine.

Other animals. The cause of pseudo-membranous conjunctivitis may be sometimes found in the action of silver nitrate in too strong solutions, or when too freely applied to the eye—this will cause a noticeable tumefaction of the eyelids. In this case, on the surface of the œdematous mucous membrane (which may be stretched till it shows ectropion), a

yellowish-white, somewhat adherent, membrane can be seen forming; this may attain a thickness of 1 mm. or more, and is accompanied by a copious secretion of limpid tears which sometimes bring away with them detached shreds of membrane. Under the membrane the roughened conjunctiva is not very red on account of the serous infiltration. The false membrane becomes detached in proportion as the palpebral tension is diminished, and resolution is complete. Vachetta mentions a case in the horse, and Nicolas has often noticed cases in this animal.

The conditions under which this membrane comes and disappears indicate its mechanical origin and that it is determined by necrosis of the epithelial layer, and also that infection plays no part in its occurrence.

Granular Lesions of the Conjunctiva.

Under this heading are classified circumscribed lesions of the conjunctiva, which stand out and in some cases resemble tubercles. These conditions are ascribed to various causes. In the dog, in which it is very frequently seen, Fröhner has described a follicular conjunctivitis. It consists in a tumefaction, or rather a hypertrophy, of the lymphatic follicles, which may attain the size of a grain of millet and give the mucous membrane a dull appearance. Especially seen on the deep face of the membrana nictitans, the frequency of its occurrence is such that it has been met with in 40 per cent. of the dogs treated at Fröhner's clinique at Berlin. Pet and house dogs are most subject to it. It is often ignored because it is not accompanied by any abnormal secretion; sometimes, however, it produces a slight catarrh, and in other cases the follicles can be seen enlarged in the form of small tumours.

Follicular conjunctivitis is a cause of entropion (Fröhner). Fröhner's statement is not accepted by all clinicians—that the follicles represent pathological lesions. Hoffmann remarks that the number of dogs shewing enlarged follicles is so great that the phenomenon must be regarded as physio-

logical. [This is probably correct]. Schmidt has shewn their great frequency in the normal conjunctiva of a series of domesticated animals. The same conditions are met with in man except that the follicles are seen on the palpebral conjunctiva and in the culs-de-sac, and the same doubt exists as to their interpretation.

Schmidt-Rimpler has seen these follicles in 27 per cent. of the children, who were healthy in appearance, attending the schools in Hesse-Nassau. However, Axenfeld succeeded in inoculating follicular conjunctivitis in man, though Fröhner's experiments gave no positive results in dogs. To combat the catarrh slightly astringent washes are used $2\frac{1}{2}$–5 per cent. solution of borax; $\frac{1}{2}$–1 per cent. solution sulphate of zinc. Fröhner recommends touching the follicles with nitrate of silver or a crystal of sulphate of copper.

Conjunctivitis due to too frequent instillations of *eserine* and *atropine* have been seen in man, and these sometimes assume a follicular form.

Granular conjunctivitis of man—also called *trachoma*, on account of the roughnesses which are found on the surface of the mucous membrane—has its seat of predilection on the conjunctiva of the upper lids, and at first is somewhat like the follicular form, but is distinguished from it in appearance, tenacity, serious disturbance of the sight, and contagiousness. It was at one time common in armies on campaigns and on this account has been called "military or Egyptian ophthalmia." It still exists in an endemic form amongst poor tribes of natives in Syria and Egypt. But it may be met with anywhere and seems to be "the most widespread disease of the eye on the face of the globe" (Morax).

Whilst follicular conjunctivitis is without danger, trachomatous granulations irritate the cornea, which becomes inflamed and covered with a pannus; disfiguring fibrous bands resulting from the granulations are found scattered in the palpebral mucous membrane.

Trachoma has no characteristic anatomy; its granulations are formed of agglomerations of cells like those of folli-

cular conjunctivitis, and its cause has not yet been determined. [Gray has, from a clinical study of a great number of cases in dogs, come to the conclusion that granular conjunctivitis is only an advanced or more chronic form of follicular conjunctivitis. Some observers, from a microscopical examination of these two forms, find the difference between them to be one of degree in the hypertrophy of the sub-epithelial adenoid tissue, which exists in both].

The granular conjunctivitis reported in horses—chiefly by veterinary surgeons practising in tropical countries, has nothing in common with the preceding, the human affection not being inoculable to animals (Morax). According to Quérand's observations in 1906 it should be considered as a conjunctival localisation of granular dermatitis, for it is usually accompanied or preceded by "summer sores" about the head. The palpebral conjunctiva, bright red in colour, has yellowish granulations situated in the substance of the mucous membrane and surrounded by a clearer ring of serous exudation. At the same time an irritative reaction of the bulbar portion of the conjunctiva and of the sclerotic is found in the corresponding regions. The eyelids are closed, extremely œdematous and very painful.

At a more advanced stage very irregular ulcerations are seen, of which the purplish walls bristle with small prominences containing the same granulations, as before, about the size of a grain of millet. The ulcerations are also found on the membrana nictitans on which they attain a great size. In the granulations, as in "summer sores," are found traces of the *Filaria irritans*, the causal action of which was shown by Rivolta and Laulanié.

The affection has the same course as "summer sores," *i.e.*, it occurs in the summer months, but it is less resistant to therapeutic treatment. Quérand has obtained a cure in 8 days by simply touching the granulations with a copper sulphate crystal, which has no effect on the granular cutaneous wounds. In horses also Rivolta and Togneri in 1891, described a granular and ulcerative conjunctivitis at an advanced stage in the

formation of a lymphatic cord, extending from the temporal canthus of the eye to the base of the ear and sometimes undergoing suppuration. This (very contagious) affection was attributed to epizoötic lymphangitis (?)

Exanthematous Conjunctivitis.

Under this heading are included all the inflammations of the conjunctiva which accompany the development of eruptive diseases on the mucous membrane. The conjunctival eruptions of horse-pox (Labat), of foot-and-mouth disease, of sheep-pox, and of cow-pox (Röll), pursue the same cycle of development as elsewhere, and are accompanied by the symptoms peculiar to each eruption as well as by a catarrhal or purulent inflammation. [It is conceivable that the ulceration of the cornea in dogs suffering from distemper is of this nature]. It is not without danger to the eye, and the formation of vesicles and pustules must be watched with care to avoid complications.

In the dog, Brusasco and Fröhner have described a *phlyctenular conjunctivitis* which is very rare, and recent observations might suggest their being compared to the affection of the same name frequently seen in children. In children it accompanies the eruption due to impetigo contagiosa of the scalp, face, nose, ears, etc., from which it is called lymphatismal or scrofulous conjunctivitis. It is characterised by the presence, on the bulbar conjunctiva, of small elevations with clear or opaque contents (the affection may assume a pustular form), usually discrete and bordered with small brush-like vascularities. After some days the summit of the pustule falls off, and small ulcers are left which as a rule cicatrise without complication. A slight catarrh, and an intense photophobia when the eruption is situated near the corneal limbus, completes the symptomatology. The general state of the child is often the cause of numerous recurrences.

[The various forms of conjunctivitis arising during the course of acute general infections, such as distemper or influenza, are not essential manifestations of such acute general infections; they are the manifestations of secondary infections

playing on a lowered vitality set up by primary acute general infections and can only be overcome by the abatement or disappearance of the primary general infections. In reality, they usually disappear without any local treatment, or in spite of it. Remembering these facts, one should understand why they cannot be controlled by active treatment; all one can do is to adopt soothing, mild antiseptic treatment, and to remove the pain by means of cocaine, novocain or alypin].

Traumatic Lesions.

Foreign Bodies.—On the surface of the conjunctiva either living or inert foreign bodies may be met with. The living include filaria, frequently met with in the conjunctival culs-de-sac and under the membrana nictitans in ruminants, and sometimes in the horse; spiroptera in birds, in which they cause the serious purulent conjunctivitis already described. In Algeria, Calvalin has found leeches 1.5 cm. long, fixed to the inferior palpebral mucous membrane of a horse, and also to that of two mules. Inert bodies are most frequently oat-flights or particles of chaff. Harrison found a porcupine quill in the conjunctiva of a dog. [Gray witnessed a case in a young dog, in which the offending body was a particle of hay behind the membrane nictitans. Where wooden mangers are used splinters, as a cause, are not infrequent (Smith)].

Foreign bodies cause more or less intense reactional symptoms which speedily attract attention—photophobia, lacrimation, muco-purulent or purulent secretion, swelling of the eyelids, opacities of the cornea, etc. In some cases the symptoms may at first sight be so marked as to raise suspicion of a serious intra-ocular lesion.

Foreign bodies may be apparent to the observer with an ordinary examination or inspection; in many cases in large animals diagnosis is not certain till a digital exploration has been made.

Once recognised, the foreign body is withdrawn by the exploring finger, or in some other way suitable to the case—by forceps, by a jet of boracic solution from a syringe or irrigator, or with a feather.

Wounds from scratches with the finger nail [or from the claws of the cat], branches of trees, straws, pointed or cutting instruments, etc., present nothing peculiar except that they are accompanied by subconjunctival ecchymoses in a good many cases. These may also be caused by contusions, or may even be symptomatic of general infections such as purpura hæmorrhagica, or the trypanosomiases (Cazalbou).

Burns and *Corrosions* occur under the same conditions as in the cornea (*see later:* corneal opacities), but in this case the ulceration consecutive to the falling off of the scab at the time of its cicatrisation may give rise to sequelæ, such as adhesion of the eyelids to the eyeball, or entropion. The history of the case will decide the diagnosis. The corrosive substance must be removed with forceps or by a stream of boric solution, and then its effects must be neutralised by a few drops of milk if the foreign matter be an alkali, or with an oil if it be lime. During the healing of the wound adhesions may be prevented by frequently moving the surfaces in contact, and by keeping the wound covered with some lubricating material in the form of a mild antiseptic ointment [or castor oil].

Ulceration of the Conjunctiva. This is seen in some forms of conjunctivitis, chiefly with the exanthematous variety, and when false membranes are formed; following burns and corrosions; in conjunctival tuberculosis. Hansell, inoculating tuberculous material to the conjunctiva in rabbits, always found that an ulcer developed, and that at its base were scattered grey or yellow granulations.

New Growths.

Tumours. Meyer and Müller have described lipomata, but the best known are tuberculous nodules in ruminants, sarcomata (Lüpke), and epitheliomata (Leisering, Bayer, Le Calvé, Petit and Coquot) in the horse. [These are also frequently seen in the dog, and occasionally in the cat]. The epitheliomata usually have their origin on the corneo-scleral limbus; they remain external, or only invade the superficial layers of the cornea (Le Calvé), or may reach the interior of the eye (Petit and Coquot) at the junction of the sclerotic with the cornea.

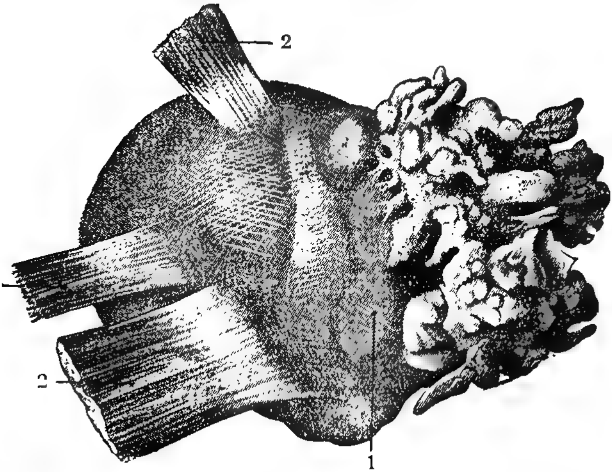

Fig. 58. Cancer of the conjunctiva in a horse (Petit and Coquot).

1 Part of the cornea not invaded by the cancer.

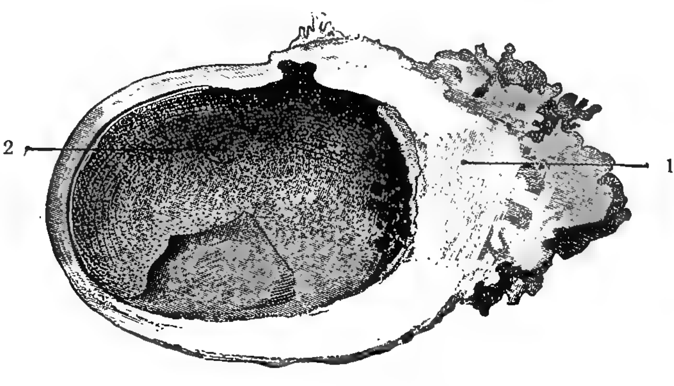

Fig. 59. Longitudinal section of the above eye.

1 The tumour has invaded the anterior chamber and has destroyed the cornea and iris.

Externally they have a granulating, repulsive appearance. The presence of one of these growths almost always entails the removal of the eye, for if the growth only is excised recurrence is to be expected in very many cases (Le Calvé). However, as a first step the more superficial parts of the growth may be removed and the base of the wound curretted.

Pterygium or Pterygion.

Amongst the cases of pterygium recorded in veterinary literature, some are in reality tumours of the conjunctiva and others are dermoids. The only true cases are those of Möller and Vachetta in the horse, and of Möller in the dog.

A *pterygium* [wing] is a triangular fold of the conjunctiva, the summit of which extends on to the cornea and towards the centre of which it is attached. Its base is continuous with the conjunctiva and the middle portion of it is free and only touches the subjacent parts. It is invariably situated in the palpebral fissure, as a rule inside, but sometimes on the outside. [G. D. Whitfield has seen it in the inner margin of the cornea of a white stud mare.]* It develops progressively without any inflammation, and only causes inconvenience when it covers some part of the pupillary field. Its pathogenesis is still unknown.

Treatment necessitates the excision of its apex and curetting its point of attachment to the cornea ; then the excision of the base and the reunion of the lips of the conjunctival wound. In man recurrence is not rare.

Congenital Affections.

Dermoids.—These are not rarely observed in animals, since Kitt (1901) was able to collect 24 cases occurring in the ox, dog, sheep, pig, and cat. [They are not rare in foals].

They have the appearance of skin and their surface is always furnished with the hairy covering peculiar to the species on which they are found ; usually thin, long fine hairs, bristles in pigs, and wool in sheep (Garson). Their predilection seat is the sclero-corneal margin in the temporal

* *Veterinary Journal* Vol. XI., 1881.

angle of the palpebral fissure; but they have been met with exclusively attached to the cornea (Emmert), which they may in some cases almost completely cover (Schmidt-Rimpler); they may also be seen in the nasal angle (Bru, Schimmel and Over). [They sometimes extend to the membrana nictitans]. One eye is usually affected, sometimes both. Lastly, several may be found on the same eye (Bru). [They are generally in one continuous patch, but sometimes divided in the form of a cleft].

[G. L. Ingram has reported that in three cases, occurring in fox-terriers, the growths were attached to the cornea at their

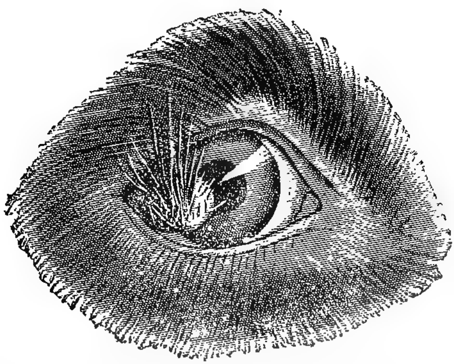

Fig 60. Conjunctivo-corneal dermoid (Cadiot and Almy).

peripheries only; and that when excised an area of perfectly healthy cornea was left, enclosed in a ring denoting the attachment of the dermoid. J. M. Parker (*Veterinary Journal*, Vol. iv. p. 395) saw a case in a setter pup where the whole eye was covered with the dermoid].

Dermoids are in some cases accompanied by other congenital anomalies and may be transmitted to the offspring. [If left alone they usually increase in size as the animal develops]. Their formation may be explained by a fœtal inflexion of the external layer of the blastoderm (Remak), or by an adhesion of the amniotic sac which, later on, stretches

and breaks (Van Duyse). [When microscopically examined they have the structure of skin and contain in some parts pigment, sebaceous and sudoriparous glands and long hairs. They are by some authorities considered to be a reversion to type, as in some of the reptilia and other of the lower animals the cornea is normally covered by true skin. In the dog they are chiefly seen in the hound class].

Treatment consists in the excision of the growth under a continuous jet of water (Labat), these tumours being very vascular. [In the foal, calf, and sheep they can easily be stripped off after being cut into, the eye being previously anæsthetised by means of cocaine or its substitutes—novocain, alypin and adrenaline. In the dog and cat it is often advisable to operate whilst the animal is under the influence of a general anæsthetic. After-treatment consists in applying mild anodyne collyria]. An opacity of the cornea is always left but recurrence is rare.

CHAPTER VI.

THE SCLERA AND CORNEA.

The Sclera or Sclerotic.

Anatomy.—The Sclera is the external opaque covering of the eye. It is a very resistant, white, fibrous membrane, somewhat resembling mother-of-pearl, and its thickness varies in different places and of course in different species. As a rule it is thickest round the optic nerve and in the region of the posterior pole, and thinnest at the equator of the eyeball. Round the cornea it again becomes thick. In the horse Koschel has found it to be 2mm. thick at the posterior pole, .4mm. at the equator and 1mm. at the circumference of the cornea; in the ox, 2mm. at the posterior pole, 1 mm. at the the equator, and 1.3 mm. round the cornea. In the dog and cat it is the same, but the circumcorneal thickening is limited to a ring only about 5–7 mm. broad, and this exceeds the posterior polar thickening.

On the other hand, the temporal region, where the eye is more uncovered and possibly more vulnerable, is always thicker than the nasal region which is better protected. Anatomically the sclerotic presents two surfaces and two openings for consideration.

The external surface is convex, gives insertion to the muscles of the eye and is in contact with the adipose tissue of the orbit. It is traversed by all the vessels and nerves of the eye; behind by the posterior ciliary arteries and the ciliary nerves which form a complete ring round the optic nerve; in front near the sclero-corneal limbus by the anterior ciliary arteries; in the middle region by the choroidal veins or the vasa vorticosa, four in number, two superior and two inferior, these latter being nearest the optic nerve.

The internal or concave surface is lightly bound to the choroid by means of a wide-meshed tissue known as the *lamina fusca.*

The anterior opening has its margin bevelled at the expense of the internal surface to receive the cornea [which fits into it like a watch glass into its frame]. The posterior opening, or scleral foramen, which gives passage to the optic nerve does not exactly occupy the posterior pole of the eye. It is always situated in the inferior hemisphere and usually is inclined towards the temporal side, except in man, monkeys, the elephant and whale, in which it is more towards the nasal side. According to Koschel the posterior or scleral opening

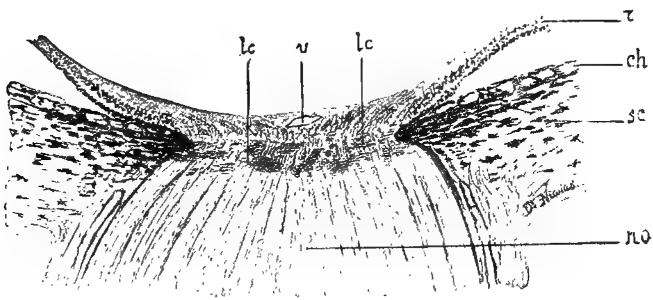

Fig 61.—Section through the optic papilla of a sheep. ch, choroid—lc, lamina cribrosa. no, optic nerve. ι, retina. sc, sclerotic, deeply pigmented. v, central vessel of the papilla.

is found from 10–13.5 mm. *below* the horizontal meridian in the horse, 7 mm. in the ox, 6.2. in the sheep, 2.9. in the pig, 1.5–2 in the dog, 1.0–1.8 in the cat, and from 0–08 mm. *outside* the vertical meridian in the horse, 2 in the ox, 1.3 in sheep, .5 in the pig, 0.02–0.07 in the dog, 0–0.8 in the cat.

The scleral foramen is closed by a fenestrated membrane through the perforations of which the fibres of the optic nerve pass; this is the lamina cribrosa which never occupies much of the depth of the sclerotic. (See Fig. 61).

Structure.—The sclerotic is made up of layers of connective

tissue so united that they cannot be divided up into concentric lamellæ ; to these are added some elastic fibres and pigment.

The pigment is always plentifully found in ruminants in which it sometimes invades all the layers of the membrane, as in the horse and dog where it is as a rule found scattered in the parts bordering on the cornea.

In birds there exist under normal conditions some osseous plates which form a ring round the anterior and posterior openings. But in all animals, as in man, these osseous formations may be met with at the back of the eye, either in old age or in some inflammatory conditions of the eye. The scanty vascular supply is derived from the anterior and posterior ciliary vessels; the anterior form two superposed loops of vessels, one superficial, the other deep, round the circumference of the cornea. The deep network is more developed in animals than in man, and sends vascular tracts into the cornea; these are well developed in the calf and sheep, in which they sometimes reach the centre (Deber).

Disturbances of Nutrition and Inflammation of the Sclera. (1). *Hyperæmia.*—Visible only on the edge of the circumcorneal ring, this is especially common in the horse. It is often co-incident with hyperæmia of the conjunctiva, from which it has to be distinguished. The turgescent scleral vessels have a purplish tint due to their transparence; further, they are fixed (whilst the vessels of the conjunctiva are mobile, when the membrane is displaced) and of a bright red colour.

Scleritis is practically unknown in veterinary medicine, and it may be mentioned that when congestion of the sclera is seen it is always symptomatic of an intra-ocular affection, generally of the iris or the ciliary body.

(2). *Scleritis.*—Inflammation of the sclerotic is an essentially chronic affection, which in man is shewn anatomically by an accumulation of leucocytes at certain well defined points, and clinically by small congested protuberances, is not [or very rarely] met with in the domesticated animals. The reason for this is probably to be found in the fact that they are not

attacked, at least not to the same extent as is the human subject, by diatheses or chronic infectious diseases—such as lymphatism, rheumatism, syphilis, which play such an important *rôle* in human ophthalmology. But it is not impossible that tuberculosis, so common in bovines, may be manifested, as the other diseases are in man, in the form of scleritis. The attention of veterinary surgeons might be drawn to this point.

(3). *Staphyloma.*—This name is applied to an ectasia of the sclerotic. It is always the result of some defect in the equilibrium between the intra-ocular pressure and the resistance of the membrane. Sclerectasia may be total (as in buphthalmos and hydrophthalmos), or partial. In man partial staphylomata may be anterior or posterior, and in the latter case they are accompanied by a high degree of myopia. In the horse posterior staphyloma has from time to time been reported (even by Nicolas) as having been diagnosed by means of the ophthalmoscope, but it does not exist. Scleich has on two occasions seen (with the ophthalmoscope) in dogs posterior staphyloma, congenital in origin, and co-existent with other malformations. In these cases ophthalmoscopic diagnosis was confirmed by post mortem examination. Von Gräfe also met with one case when making an autopsy of a pig. The sclerectasia situated near the optic nerve was caused by a tuberculous swelling originating in the choroid and pushing the retina forward and the sclerotic back. The last named membrane had undergone pressure atrophy.

(4). *Tumours.*—In the few cases of neoplasms, occurring in the sclerotic, reported in veterinary literature, the growth may be considered as having originated in the neighbouring tissues. The selerotic acts as a barrier to the spread of neoplasmata and is only with difficulty invaded by them (Lagrange).

Traumatic Lesions. The *Sclera* may be bruised or wounded. Contusions may produce simple sub-conjunctival ecchymoses, intra-ocular hæmorrhages, rupture of the zonula, or luxation of the lens, without there being any solution of continuity of the membrane. But in spite of its resistance

they may cause direct or indirect lacerations or ruptures of the membrane. Roquette, by submitting the eye to gradual pressure, has seen the eye of an ox refuse to yield to a pressure of 25–27 kilos., whilst that of a man will rupture with 8–9 kilos. Ruptures are generally produced in the vicinity of the sclero-corneal limbus (Bayer). In two cases seen in horses by Berlin they were situated in the internal angle of the eye.

Contusions are due to the animals injuring themselves against obstructions, and more often to blows with the whip handle or other brutalities on the part of the driver.

Wounds are caused by pointed or cutting instruments, or sabre cuts in cavalry horses (Müller); by blunt instruments; sometimes by bullets or shot in sporting dogs.

If they perforate they are soon followed, according to their position, by the escape of the aqueous humour, hernia of the iris, of the ciliary body or choroid (which soils the edges of the wound with pigment), and even of the vitreous humour; œdema of the eyelids, chemosis of the conjunctiva, a blood-stained discharge on the surface of this membrane, and ecchymoses into its meshes will raise suspicion of the eye being perforated.

Wounds of the sclerotic are serious chiefly on account of the danger of infection. It is therefore well to decide the diagnosis as soon as possible with the object of preventing this complication.

Treatment. The eyelids and conjunctival culs-de-sac should be carefully disinfected with a warm 1 : 4000 solution of sublimate, [or biniodide of mercury; or 1 : 2000 to 1 : 1000 chinosol]. If the wound is closed by a hernia of the iris, ciliary body or choroid, reduction should not be attempted, but the protruded parts should be excised. Then the wound should be covered with iodoform ointment and the eyelids kept closed by a dressing applied with slight pressure.

The Cornea.

Anatomy. The cornea is the transparent membrane which closes the eye anteriorly. Its radius of curvature is less than that of the sclerotic, and consequently it stands out

from this membrane. Its form is that of a watch glass—almost spherical in the dog and cat (as in man), and ovoid in solipeds and ruminants, in which the major axis being horizontal and the more rounded end of the ellipse turned towards the nasal angle, the horizontal meridian is about half as long again as the vertical. In these latter animals the asymmetry of the cornea is well marked, and seems to bear some relation to the semi-lateral position of the eyes, and it also gives a larger visual field and assists bilateral vision (Kalt). The curvatures of the cornea are usually unequal, the vertical being, as a rule, the smaller—this gives rise to a physiological astigmatism (*see* pp. 37 and 84).

The relative size of the cornea is variable. Its diameters compared with those of the eyeball are as 1 : 1.3 in fish, 1 : 2 in mammals, except in ruminants, in which it is 1 : 1.4.

The cornea presents a perfectly smooth, glistening free surface, and is transparent throughout. In the horse, however, the corneal border towards the limbus presents two greyish-white, almost opaque, curved lines, which are at least 1 mm. thick. In the foal these lines are not discernible, but increase in density and outline as adult life is obtained. They are quite excentric, and in appearance are not unlike the *arcus senilis* in man, but differ from it in that the latter is concentric, and separated from the corneal border by a thin band of healthy cornea. [In one class of fishes, the *Anableps*, the cornea is divided by a transverse opaque line, and the iris has two perforations or pupils.]

Structure. The cornea is made up of several distinct layers which are from without inwards: (*a*) the *Epithelial layer*, made up of three kinds of cells, prismatic in the depths, cubical (with crenated edges in the horse) in the middle region, and flattened on the surface; (*b*) the *Membrane of Bowman*—this is homogeneous, and in it are buried the terminations of the prismatic cells; (*c*) the *Tissue proper of the cornea*, formed by transparent connective tissue fibres which are united into bundles and lamellæ; these lamellæ are superposed one on another, and have some connections between one plane and

the next. Between these bundles and lamellæ, lacunæ and canals are found, forming a continued space and containing lymph and two kinds of cells, one (fixed) variety, rare in the horse and ox but more abundant in the dog, cat and man, is corpuscular in type in the horse and ox or membranous in the dog and in man. The other variety is motile (true leucocytes) coming from the general circulation (Ranvier). (*d*) The *Membrane of Descemet* is a homogeneous hyaloid membrane, brittle, like cartilage, very thick in the horse (1/8th the thickness of the whole cornea), and consequently very resistant; (*e*) the *Posterior endothelium*, flattened and only forming a lining to the posterior face of the membrane of Descemet; it protects the cornea from the action of the aqueous humour.

Blood vessels do not exist in the adult under physiological conditions, or at any rate are not visible; their presence always denotes some pathological alteration.

The cornea is nourished through the lymphatic canals which form, as has been said, a complete system in its substance, communicating with the peripheral sub-conjunctival lymph spaces. When intra-ocular pressure is increased, as in hydrophthalmos and glaucoma, the cornea loses its transparency; the same result can be experimentally obtained by digital pressure on the surface of the eye. The nerves, which are very numerous, come from the ciliary nerves and penetrate all the layers of the epithelium, even the most superficial. On this account ulcerations of the cornea are [generally] very painful and are accompanied by reflex symptoms—blepharospasm, miosis, lacrimation, etc.

Clinical Examination of the Cornea.—To notice all the alterations of the cornea it is necessary to examine it from several points of view. *Form:* It may be the seat of invasion of tissue and vessels of new formation advancing from the periphery to the centre and altering its shape from the normal. *Dimensions:* The cornea is considerably increased (keratoglobus) in hydrophthalmos and shrinks with atrophy of the eye and microphthalmos. *Curvature:* Only a relative idea of this can be obtained, for example by comparison with the

other eye, or with the eye of a healthy animal. On bringing a lighted candle up to the cornea the membrane forms an image of the flame (see Purkinje's images); this image is increased if the cornea is flattened and diminishes if the radius of curvature is shorter. The distance of the candle from the eye, however, affects the picture. *Evenness:* Purkinje's images, by becoming deformed or remaining regular in outline, will give some information on this point. But a better idea as to regularity may be obtained by placing the animal in a doorway and practising oblique illumination with the naked eye; or better, by the direct illumination with an ophthalmoscope. By this last method, prominences, excavations, and facets, all give rise to shadows which are thrown on to the pupillary field of the observer's eye, and which can easily be localised in the cornea by the method of parallatic displacements. *Polish:* A cornea which has lost its characteristic polish—is less bright, has the appearance of having been pricked with a needle if the lack of lustre is due to small excavations, or a shagreened appearance if the change is caused by elevations. *Sensitiveness:* Normally this is extreme; it is increased in ulcerations, but in glaucoma it is diminished (Fuchs). [In some breeds of dogs, however, especially those having prominent eyes, the normal sensibility appears to be relatively less than in those breeds in which the eyes are deeper set].

Keratitis: Inflammation of the Cornea in General. The cornea on account of its transparency has been chosen as a field for experiments in the study of the development and course of inflammatory phenomena. It may be well to consider these here.

Stage of Infiltration.—Every inflammation of the cornea begins with a loss of transparency, caused by the accumulation throughout its substance or limited to one point, of migratory leucocytes coming from the circumcorneal vessels by diapedesis, as Cohnheim states, or rather from the proliferation of fixed cells, or according to Hœnsell, from the stroma returning to its embryonic condition. This is the

stage of infiltration. If the collection of inflammatory elements is confined to or abundant in one point, the cornea may be deformed at this point; it stands out slightly from the surrounding parts and the epithelium may desquamate superficially, leaving a dull lustreless surface. This corneal infiltration has a tendency to become resorbed or to increase.

Resorption is indicated by diminution of the opacity or by its disappearance if resorption is *complete;* in this case the cornea completely recovers its physiological condition. But if resorption is only *partial*, the infiltrated elements become organised; there is a formation of interstitial cicatricial tissue which gives rise to a permanent opacity, capable of becoming clearer in time, but rarely disappearing entirely. In cases in which conditions are favourable infiltration *progresses* and the *stage of suppuration* is reached. This will be considered under the head of ulceration of the cornea.

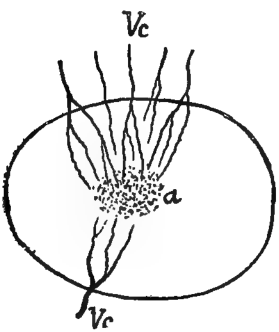

Fig. 62. vc, superficial conjunctival vessels extending to a corneal lesion (*a*).

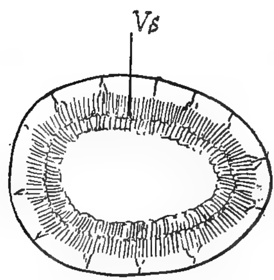

Fig. 63. vs, deep scleral vessels forming two series with their nutrient trunks.

Inflammation of the cornea is accompanied by very important symptoms.

Formation of new vessels.—The presence of blood vessels in the cornea always denotes a pathological condition. They may be situated superficially under the epithelial layer, as in

pannus, and then they come from the conjunctiva; or deep in the stroma, as in parenchymatous keratitis, when they are scleral in origin. Their position is fairly easy to recognise from the following differential characteristics—superficial vessels are fairly large, rather tortuous, ramifying like the branches of a tree, and they are of a bright red colour.

They are usually localised, and can be followed in the conjunctiva beyond the sclero-corneal limbus, [over which they pass to gain the cornea]. The deep vessels are fine, grey in colour, generally short, straight, and placed in regular rows; sometimes other vessels, placed wider apart and branching, take the place of the first, of which they seem to constitute the nutrient trunks. They emerge from under the limbus, and are met with, the second variety more commonly than the first, in all fairly acute inflammations of the iris and ciliary body as well as in all cases of suppuration of the cornea. Lastly, they may in some cases resemble a besom, [which is generally an indication that they are of long standing].

Injection of the ciliary and conjunctival vessels proceeds from the same cause which gives rise to the vessels above mentioned. The new formation of deep vessels is always accompanied by congestion of the ciliary vessels, and that of superficial vessels by injection of the conjunctiva.

Iritis and Irido-cyclitis.—Inflammation of the cornea has almost always some influence on the iris and ciliary body. In cases in which this effect is at its minimum these membranes are the seat of a congestion which is shewn by contraction of the pupil and by its remaining contracted, and above all, by the resistance which it shows to the action of atropine; but inflammation of the iris and ciliary body is especially noticeable when there is suppuration of the cornea, and is manifested by the formation of an exudate in the anterior chamber (keratitis with hypopyon).

Reactionary symptoms.—These are [nearly] always well marked by *acute pain* especially with ulcerations—the least attempt at examination being resented by the animal; intense *photophobia*, shewn by spasmodic contraction of the

eyelids, this being in some cases difficult to overcome; abundant *lacrimation* and disturbance of vision, this last being due to opacities. Any inflammation of the cornea is included under the term keratitis. Keratitis is met with under various forms; the division into superficial, middle and deep, according to whether the epithelium, the stroma, or the membrane of Descemet is affected, is a little too artificial.

In the following account keratitis will be described under the heads of non-suppurative and suppurative, as this division responds better to the forms clinically distinguishable and also gives an idea of the appearance of the cornea and the extent of the lesion.

Under the heading of *Non-suppurative Keratitis* are included superficial keratitis, the vascular form or pannus, keratitis with formation of vesicles, parenchymatous keratitis, keratitis pigmentosa, keratitis punctata profunda. Under *Suppurative Keratitis*, abscesses and ulceration of the membrane, keratitis neuroparalytica, and keratitis with lagophthalmos.

Non-Suppurative Keratitis: Superficial. This form is limited to the epithelium or to the most superficial layers of the parenchyma.

Symptoms. A bluish-white cloudiness, as a rule localised, accompanied by lacrimation and slight photophobia, may be all that is seen. Complete resorption occurs after a few days, leaving no traces. An epithelial desquamation may be produced on the surface of the corneal infiltration; sometimes it is so superficial that a very careful examination it needed to discover it. The desquamated part is always a little dull, but it can be recognised by the depression at its edges. If it is desired to show this desquamation more clearly it may be done (as is the practice in human ophthalmology, and as Dupuis has done in veterinary work) by instilling a drop of 1 per cent. solution of fluorescein. This only imparts its colour to the parts deprived of epithelium. The affection, lasting four or five days, disappears without leaving any trace.

Etiology. In this degree keratitis is frequently met with in the horse. It results from conjunctival catarrh, contusions of

the orbital arch and of the upper eyelid, direct wounds from chaff, cauterisation of the conjunctiva with nitrate of silver—in short, from any mechanical or chemical irritant, if not of too great intensity.

It is probable that it was this slight superficial or conjunctival form of keratitis which was seen by Piot-Bey in the Nile valley, in which an opacity of the cornea with slight conjunctivitis "attacked in a single night ten, fifteen or twenty horses, and disappeared on being treated with simple antiseptic lotions without leaving any traces." The same may be said of white spots appearing periodically on the cornea in dourine (Tschernogorow), and in nagana and surra (Roger and Greffuhle). [Motton mentions a case occurring in a horse affected by tetanus; both eyes were attacked].* Subacute inflammations of the iris and ciliary body have as their most apparent symptom a superficial infiltration, the appearance of which is fairly characteristic of the cause. The disturbance is localised to one or more well-defined foci, sharply defined on their margins and always connected to the sclero-corneal limbus by a wide base. The surfaces of these foci are convex and alternate, with absolutely transparent portions of the cornea, which in contrast appear to be plane surfaces. Through these healthy regions of the membrane the symptoms of the uveal inflammation can be recognised.

Treatment. The condition recovers with the careful use of antiseptic lotions and instillations of borax 1 : 100 to 1 : 200 or chinosol 1 : 2000 in boiled water. In cases in which keratitis is symptomatic of uveal inflammation collyria of cocaine and atropine (1 : 200) should be instilled two or three times daily. In any case in which the least sign of ulceration is shown lotions, containing any lead [or silver] salt should be avoided, as they cause opacities [or stains] which cannot be removed. [Further, zinc, and especially nitrate of silver, intensify the trouble (Smith)].

* *Veterinary Journal.* p. 105, Feb., 1911.

Vascular Keratitis or Pannus. This is constituted anatomically by a newly-formed vascular tissue situated, according to Ivanoff, who has studied the subject in man, between the corneal epithelial and the membrane of Bowman.

Symptoms. If of recent origin, pannus appears in the form of a greyish or whitish opacity, having a shagreened surface, traversed by relatively large sinuous vessels divided like the branches of a tree and connected with the conjunctiva, into which they can be followed over the sclero-corneal limbus (Fig. 62). But if the cause of the pannus has disappeared the new tissue becomes organised and takes on a cicatricial appearance, and the vessels become fewer in number. According to the thickness of or the density of the tissue the pannus is called *P. tenuis* or *P. crassus.*

Etiology. This form of keratitis has up to now attracted little attention in veterinary practice, in spite of the fact that in the dog all the conditions likely to cause it are present in entropion. [Yet it is rare, in spite of the fact that conditions favourable to its occurrence in man commonly occur in the dog and cat. Probably this is due to the fact that the eyeballs in quadrupeds can sympathetically retract, and in consequence the membrana nictitans is raised and thus preventing the corneal membrane being too unduly irritated by the offending eyelids].

Nicolas has seen a thick pannus develop in the upper part of the cornea of a horse following the sub-conjunctival injection of cyanide of mercury, which caused an acute conjunctivitis, and also from the animal rubbing the eye. When the corneal and conjunctival inflammation had subsided and the pannus had become organised, it looked as if an outgrowth of cicatricial tissue had arisen from the conjunctiva, and the part of the cornea invaded became quite opaque. [Tumours on the upper eyelid of the horse rubbing on the cornea may give rise to it].

Any cause of irritation of the cornea acting with intensity for a long time and always at one point may cause it; thus it is that granular conjunctivitis in man invariably (?) causes on

the superior border a pannus which is often the sign of the presence of the granulations. [A similar condition is observed in the dog after the repeated applications of powdered glass or sugar to the eye with the pretended object of removing opacities and various other inflammatory lesions. Again, all these characteristics are encountered in the same animal, resulting from the continual rubbing of the eyes with the paws in eczema or mange affecting the eyelids]. The same thing happens in *trichiasis* or *distichiasis*, which, however, rarely cause inflammatory lesions in the cat and dog.

Treatment.—The first step must be to remove the cause. For opacity, if thin and of recent origin, irritant, resorbent ointments should be used; red oxide of mercury, 1 : 500 of vaseline. [This is rarely used in veterinary practice in Great Britain. In place of it yellow oxide of mercury 1 : 20 to 1 : 60 (Pagenstecher's ointment) is preferred. The weaker strengths are often better tolerated. Better results are, however, obtained by the use of atropine, at least during the earlier stages].

If the pannus is essentially vascular, peritomy gives good results. (*See later :* Surgery of the cornea). [Gray, on the contrary, has never found it successful]. Lastly, if the pannus is reduced to almost purely cicatricial tissue, it may be removed by curettage by means of a small Volkmann's spoon, or with a bistoury applied tangentially to the cornea; or the opacity can be hidden by tattooing if cosmetic appearances are desired.

Superficial Keratitis, Keratitis punctata superficialis, or Facetted Keratitis.

This form has been chiefly studied in Germany in the horse by Bayer, Fröhner, Lohoff, Guilmot and Schwarznecker. Bertreux and Bidault in France have had one typical case, communicated to Nicolas. The slightly different names applied to this condition arise from the appearance of the cornea which has most forcibly appealed to the different observers. [This has also been observed in the dog, especially the Pekingese].

Symptoms.—The affection is characterised by more or less generalised cloudiness of the cornea, in the midst of which small spots can be distinguished on careful examination, which are more or less dense, or opaque, white, grey, or even yellowish, forming a slight relief on the surface of the cornea, and penetrating the parenchyma to a greater or less depth. These points may ulcerate (Lohoff). They are irregularly scattered and leave between them portions of mirror-like tissue, which gives the cornea a facetted appearance. These facetted portions, which may be taken for small ulcers in process of cicatrisation, are in reality areas of sound cornea; in every case fluorescein will leave no trace in their centres. (Bayer). Briefly stated, the opacities are irregularly scattered, and by its loss of polish the cornea resembles a shagreened surface which causes the corneal images to be deformed.

Reactionary symptoms attract more or less attention. There is slight photophobia and lacrimation. Bayer has seen no scleral or conjunctival vascularity, but Bidault mentions both of these symptoms. Both eyes may be attacked.

The course of this affection is essentially a chronic one, the symptoms become attenuated without disappearing completely. On the contrary, an opacity always remains and this forms a starting point for fresh attacks. This recurrent character has been noted by every observer. "The attacks which lasted three weeks, were separated by periods of about three months during which the symptoms diminished considerably without completely disappearing" (Bidault). In a case reported by Lohoff the keratitis appeared for four years after the first attack at the commencement of the winter and disappeared in the spring. [Gray has often noticed these characters in Pekingese and other dogs suffering from the complaint. On the contrary, the eye may, in certain cases, recover its former brilliance in the intervals between the attacks].

Pathological anatomy.—Under the microscope Czokor found little masses of round cells, limited to a few lamellæ, invading the anterior half or even the whole thickness of the cornea.

In the last case the infiltrating elements had the form of bottles with their necks directed towards the membrane of Descemet. Near the limbus new vessels could be distinguished, surrounded by leucocytes, in the midst of which were a few micrococci and bacilli the nature of which was not determined.

Etiology.—Although Lohoff has stated that rheumatism may be a cause, nothing is really known of the etiology of the condition. [It is not rarely encountered in dogs with prominent eyes liable to recurrent attacks of rheumatism].

Parenchymatous or Interstitial Keratitis, or Anterior Uveitis.

This form is characterised by diffuse infiltration of the stroma of the cornea accompanied by scleral vascularity. It never suppurates. It is closely allied to inflammation of the uvea. In man it is complicated as a rule with irido-cyclitis. In the horse, in which its nature has been better determined, it is almost always secondary to, or complicated by irido-cyclitis. In either case there is a diminution of ocular tension.

Symptoms.—In most cases the cornea assumes a greyish tint, sometimes white or yellowish; in any case its transparency is always diminished, especially at the periphery, and its brilliant appearance gives place to a dullness which is easily seen on comparison with sound portions. Short vessels radiating evenly towards the centre from the periphery, though quite close together, may at first escape notice on account of their fineness and their colour, which is grey rather than red. They run parallel to one another without anastomosis, and always remain at the same height, and terminate in loops. They thus form a concentric zone at the corneal limbus, almost always keeping the same thickness—about two or three millimetres—progressively advancing towards the centre; they reduce the size of the circle which they form in such a way that at length a ring is seen in the tissue of the cornea, having apparently no connection with the periphery. But they are bound to the border by ramifying

branches, at some little distance from one another and only visible with difficulty. Sometimes when the affection from which they proceed is very intense the corneal vessels form several zones; their length is cut by several concentric circles

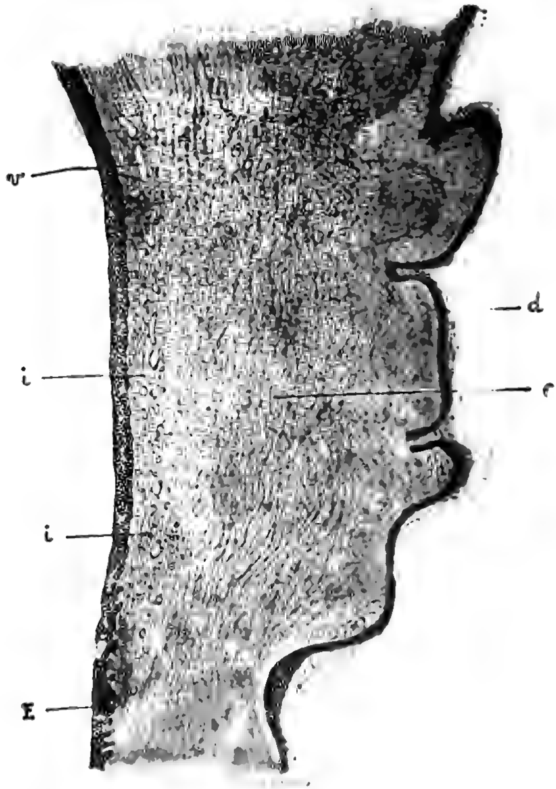

Fig. 64 —Infiltration and vascularity of the cornea of a horse from irido-cyclitis.

c. Tissue proper of the cornea *d* Membrane of Descemet, ruptured, broken in two places, and covered with exudate on both surfaces. *E* Corneal epithelium *i*, *i* Cellular infiltration. *v* Newly formed vessels.

which are more red in colour; it appears as if new vessels arose from each of these zones of loops, these again forming a more central zone (Fig. 63). In such cases the cornea is yellowish in colour, which testifies to the density of the infiltration and might lead an observer to fear that suppuration of the cornea was likely to be produced, although this termination is never seen.

On histological examination, Nicolas found an infiltration of leucocytes with formation of the above described vessels especially marked in the anterior layers of the corneal stroma (See Fig. 64).

Closely allied to irido-cyclitis in the horse, parenchymatous keratitis undergoes the same phases. After a first attack of moderate intensity, the cornea almost regains its original transparence by the resorption of the exudate and the disappearance of the newly formed vessels; but if the inflammation of the ciliary body recurs, or if the attack is very severe at the first onset, the cornea remains greyish and opaque, especially at the periphery, where it seems to form a slight swelling.

Etiology.—In man parenchymatous keratitis is almost invariably referable to syphilitic infection, sometimes, but very rarely, to tuberculosis. Some experimenters claim to have produced the condition by mechanical means. By section of the long and short ciliary vessels Wagenmann caused a greyish inflammation of the cornea in animals, followed by interstitial congestion, but the condition thus produced gradually disappeared.

Baerri by destroying the endothelium of the membrane of Descemet either by curetting, or by injections of sublimate or chlorine water into the anterior chamber, or by introducing into it small needles of glass, caused an interstitial keratitis; from this he concluded that the spontaneous affection is due to a primary lesion of the corneal endothelium by which it becomes infiltrated with aqueous humour.

Spontaneous development.—In the horse this form of keratitis always denotes a fairly acute inflammation of the iris and

ciliary body, which conditions may be secondary to an acute ulceration of the cornea or to panophthalmitis. It should be emphasized that it is in ulceration of the cornea that the particular vascular invasion of the membrane described in the preceding pages is seen; when it occurs it is not a symptom of ulceration, but an indication that the iris and ciliary body are seriously affected. In rabbits which had cultures of a pyogenic organism injected into the vitreous humour by Nicolas, the cornea remained transparent until the suppuration reached the ciliary body, and the moment this happened the cornea became opaque and the vascular crown developed within the circle of the limbus.

Nocard and Leclainche state that parenchymatous keratitis is met with in distemper in dogs, in which, with a variable degree of fever, it sometimes constitutes the only symptom of the disease; also in malignant catarrh in cattle, in which the cloudiness commences at the periphery. Möller has seen it in the course of variola in the cow and goat.

In bears (*Ursus aretas*) living in captivity, Hennicke has described an interstitial keratitis having analogies with that of man. It is exclusively seen in young animals. The substance proper of the cornea, especially in the neighbourhood of the limbus, is found crammed with leucocytes. A deep vascularization of the cornea extends almost to the centre, and the ciliary body is infiltrated.

[Parenchymatous or profound keratitis is a very prevalent disease in the dog, especially in those confined in the house and in those having prominent and mobile eyes, such as the pug, griffon Bruxellois, toy spaniels, and Japanese and Pekingese spaniels. It is also far from being rare in the Aberdeen, Irish or fox terrier, field spaniel, bull-dog and poodle. It is a very rare complaint in the cat.

It generally attacks both eyes simultaneously, and is very liable to recur. Contrary to what is the case in man, in the dog it is a disease more of advanced age than of early adult life.

Although most frequently no cause is apparent, it may

sometimes be associated with tuberculosis or with trypanosomiasis. However, according to Nocard and Leclainche* a diffuse form, manifesting itself by a milky turbidity and opalescence of the cornea, without the conjunctiva being involved, is sometimes seen as a complication of distemper. This has been shown by Uebele † not to be a primary affection, as the lesions first start in the iris and ciliary body; these are undoubtedly due to the action of toxins on the circulation.

It may, again, be associated with chronic eczema of the eyelid, ear, or other parts, but this seems quite co-incidental, for in nine cases out of ten it appears in dogs that have not, nor have ever had, eczema. It may, furthermore, be associated with a chronic purulent conjunctivitis, accompanied or not by granulations on the surface of the scleral conjunctiva. By its recurrent nature it somewhat resembles the other so-called diatheses. But it seems very probable it arises in the majority of cases from some local infection *plus* this diathesis, if this designation be still allowable. It is a progressive disease and runs a chronic course. If irritants are used in its treatment it is certain that instead of progressing slowly it will do so most rapidly. It is mostly accompanied by spasm of the eyelids, dread of light, and lacrimation, which are sometimes very severe, especially if the vascularity of the cornea is well-marked; and at other times slight, if not quite *nil*. It is occasionally linked with irido-cyclitis, and in this case may have all the sequels common to this latter affection.

The vascularity of the cornea is generally intense, at other times slight, and again in other cases quite absent. The process commonly starts at the *periphery;* occasionally at the *centre*, spreading toward the circumcorneal zone.

In the first case it is manifested by tufts of minute vessels packed closely together and resembling in outline, in magnification, a tuft of rushes radiating from its root. These give

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* Nocard and Leclainche. *Maladies Microbiennes des Animaux*, Tome I, p. 140.

† Uebele. *Keratitis parenchymatosa beim Hunde*, Thesis. Giessen, 1900.

to the cornea, a deeply situated haziness or cloudiness, which when viewed by the unaided eye has a uniformly greyish appearance, but on examination by the lens will be found to be formed of distinct dots or faint parallel lines. At the same time the limbus becomes injected, vessels commence to sprout out, giving the limbus a red, swollen and extended aspect. The deeper vessels gradually spread out from under the limbus towards the centre of the cornea, to which they do not always reach. This vascularization may confine itself to only one segment, but very often it starts from two or more quadrants, or even from the whole circumference of the cornea.

When the disease commences at the *centre* of the cornea, limited greyish opacities, having their origin in the deeper layers of this membrane, appear in this situation. These opacities increase in size, coalesce, and gradually extend towards the circumcorneal zone, ultimately giving the cornea, the surface of which is dull, a uniform cloudy, greyish or ground-glass-like appearance. After the process has progressed to some extent small vessels, originating from under the limbus, extend into the deeper corneal layers which are often obscured by the hazy outer layers of this membrane, and in consequence give to the vascular tufts a dirty greyish-red appearance.

In those cases in which there does not appear to be any vascularity, the cornea gradually becomes opalescent, starting from the centre and gradually extending to the circumcorneal zone.

When the disease is at its height the cornea becomes so turbid that the iris or pupil can be scarcely, or not at all seen; its lustre or polish is lost; it appears as if greased, and on magnification minute elevations of the epithelium give the corneal surface a rough or shagreen appearance, or in some cases appears as if stippled with minute pinpricks all over. Beginning at the periphery, gradually the vessels disappear, leaving a diffuse cloudiness and a few vessels which may ultimately vanish. In other cases the disease partially clears up, leaving several large vessels of the superficial type and

some cloudiness which seems to have come to a standstill until it becomes active again, when the corneal membrane of both eyes may take on a conical shape, or become shrunken, flattened and densely opaque.

In the non-vascular type one eye may clear up and the other remain permanently and diffusely opaque.

The vascular type, in the majority of cases recurs again and again until the transparency of the cornea is permanently lost; the vessels, which resemble in outline the arrangement of the twigs of a besom, no longer disappear, and often a few patches of pigmentary infiltration, resembling the wing of a fly, are scattered here and there in the depth of the corneal membrane. In other cases not many vessels of the besom-type are noticeable, but instead there are found a few of the superficial or forked type, radiating from the circumference towards the centre of the cornea, which may have a hazy or steamy appearance beyond a few pigmentary patches in its substance. This picture will become greatly exaggerated in those cases in which irritants such as ground glass, sugar, lead salts or nitrate of silver have been applied.

Prognosis of this complaint is not very favourable in consequence of its long duration, its liability to recur, and the ultimate damage to the sight. It is in fact one of the most unsatisfactory diseases of the eye in animals to treat.

Treatment. On no account should irritants be applied to the eye, especially in the earlier stages of the complaint, as they are very liable to render the disease incurable, or at least more intractable. More eyes are ruined by the early application of irritant drops than any other bad line of treatment. It is distressing to one to witness the damage done to eyes by improper treatment. The animal should be kept out of the glare of sunlight or firelight, and away from wind or dust, and, if possible, have its eyes shaded by means of a hood or cap.

The aim of the practitioner should be to remove the irritation and at the same time assist the vessels to constrict. For this purpose adrenaline chloride solution (1 : 10,000) and

cocaine hydrochloride (2 to 4 : 100) should be instilled into the conjunctival sac three or four times a day. If there should be any tendency to irido-cyclitis a few drops of atropine sulphate solution (1 : 200) will be beneficial. In the cases where the cornea appears to be dry, atropine or cocaine may be employed in ointment form.

When any purulent condition of the conjunctiva complicates, a mild non-irritating antiseptic is often beneficial. Biniodide of mercury (1 : 10,000) in conjunction with the application of cocaine and atropine, answers well for this purpose. Antistreptococcal and antistaphylococcal sera and vaccines might be tried.

Internal treatment is advisable. Purgatives and low diet are useful to begin with. Iodide of potassium, iron, arsenic and salines should be given. Virol, cod-liver oil, or malt containing hypophosphites are useful as nutrients.

Pigmentary Keratitis. A degenerative or inflammatory condition of the cornea, characterised by a brownish or black deposit within the layers of this membrane, usually running a chronic course and liable to recur from time to time is, like the parenchymatous form just described, very commonly encountered in the dog, principally in the black and also the fawn pug, Pekingese and Japanese spaniels, the griffon Bruxellois, and poodle, and occasionally in other breeds, especially if treated as pets and confined to the house.

It is essentially a deep vascular or parenchymatous keratitis accompanied by an infiltration of melanin within the substance of the corneal membrane. It may occur during the first two years of life, but its frequency increases with age. It usually runs a chronic course, but its progress may be arrested for a time only to occur again and again until a greater portion or the whole cornea of one or, more often, both eyes becomes involved. It may, however, attack first one eye and then the other.

As to its cause little or nothing is known, but it seems to attack preferably those dogs that have a very large amount of normal pigmentation of the conjunctiva and even sclera in

the region of the limbus. It is occasionally associated with eczema of the face, conjunctival catarrh, corneal ulceration and opacity, and superficial and deep vascular keratitis, in which cases it is then mostly of a secondary nature.

In the majority of instances, however, it appears as a primary condition, affecting only one segment, principally the temporal region of the cornea and gradually advances in a radiate, triangular or fan-like manner from the circumcorneal region towards the pupillary zone, but to which it does not as a rule reach. In many other instances it begins at two or more segments or quadrants; and more rarely at the whole of the sclero-corneal zone. It starts as a very fine brushwork of minute dark or blackish vessels spreading out gradually like a fan from under the limbus, the base being at the limbus and the apex towards the centre. These vessels are so densely packed that one is unable to see through the cornea, to which they often give an appearance as if a fly's wing had become incorporated with it. As the affection progresses the attacked portions or patches appear as if black pigment or melanin had become deposited within the corneal substance, the surface of which appears at times as if raised up above its normal level. When the disease recurs from time to time the cornea loses its lustre, becomes stippled all over with minute depressions, and is of a uniform black colour.

The ordinary corneal inflammatory reactionary symptoms—lacrimation, dread of light, and palpebral spasms are not as a rule present, or if present they are so slight as not to attract much attention. In fact, in the majority of cases the pigmentary process is well advanced before the owner notices anything amiss; in other instances its presence is overlooked in consequence of the black patches not being very apparent to ordinary persons. It is, however, easily seen by viewing the corneal substance laterally and obliquely when the animal is placed in front of a window.

The pigmentary degenerative process is sometimes followed by superficial or deep vascular keratitis affecting the non-pigmented parts, which then become slightly opaque, hazy or

steamy, and vascular in appearance. In the primary affection there is rarely any opacity.

The *prognosis* is generally unfavourable, as the disease tends more and more to destroy the transparency of the cornea either in parts or in its entire extent.

Treatment. As in iritis, irido-cyclitis, and in parenchymatous keratitis, *no irritants should be applied* to the eye. If pain, evidenced by closure of the eyelids or rubbing the eyes with the paws, be present, cocaine hydrochloride, stovaine, or alypin drops should be instilled into the conjunctival sac. The use of atropine together with biniodide of mercury (1 : 10,000) and adrenaline hydrochloride seems to act beneficially and arrests the complaint, at least for a time. If atropine should appear to increase the irritation, eserine salicylate or pilocarpine nitrate may be substituted.

Internal treatment should not be neglected. Iodide of potassium, sodium cacodylate, atoxyl, or any other organic arsenical compound, syrup of iodide of iron, cod-liver oil, or virol, and good nourishing food may be given with advantage].

Keratitis Punctata Profunda.

This is sometimes called Descemitis, but wrongly so, as the membrane of Descemet is not inflamed; it is also more reasonably called uveal keratitis or choroidal keratitis to denote the cause.

It is a sequel to uveitis in the horse, but in this case the cornea only seems to play a passive part; the exudates coming from the iris or ciliary body are simply deposited on the deep face of the membrane of Descemet and interfere with its transparence.

Symptoms.—On the deep face of the cornea small opacities can be seen by the naked eye if the subject be placed in a good light in a doorway, with oblique or direct illumination. They may be quite circular or more or less irregular, looking like small fly-blows, usually grouped together at one point of the cornea, or they may be unequally distributed throughout its whole extent. Their prominence is rarely appreciable, but they give the appearance of little flocculi of exudate

adherent to the cornea. Their colour varies from white to a rusty tint. All other parts of the eye may be normal; traces of undoubted inflammation of the uvea may be met with.

If a horse suffering from this form of keratitis is carefully watched the lesions, which may be so small that they pass unperceived, can be seen to diminish in extent, to become partially resorbed, or even to disappear completely, but they predispose to recurrent attacks of uveitis.

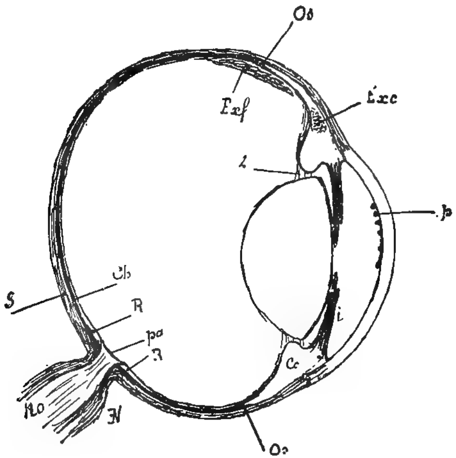


Fig. 65.—Mesial section of the eye of a horse shewing lesions of deep punctated keratitis.

p. Deposits on the posterior face of the cornea.
Exc. Cellular infiltration of the ciliary body.
Exf. Exudate organised on the surface of the choroid.

Pathological anatomy.—In a case submitted for histological examination Nicolas found small precipitates of amorphous fibrinous material on the deep face of the membrane of Descemet. At the same time he noticed a cellular infiltration of the ciliary body and of the layer of deep vessels of the choroid, as well as a fibro-cellular exudate covering the choroid in the vicinity of the ora serrata.

Etiology. Noticed by Bayer and Fröhner as a symptom of uveitis in the horse, it only began to attract notice in France when the ophthalmoscope commenced to be systematically used. It has been described by Nicolas, then by Mansis, Lenoir, and Guillaumin notably in their valuable work on enzoötic and epizoötic uveitis. Möller states that he has seen cases due to the presence of *filaria papillosa* in the aqueous humour.

Treatment. Treat the inflammation of the uveal tract if symptoms are acute. If chronic, nothing can be done for the opacities but the subject should be watched, so as to intervene as soon as possible in case of recurrence of the original affection.

Posterior Keratitis.

[A chronic inflammation of the posterior surface of the cornea has been observed by Gray to be due to a floating lens causing friction ; it may occur in one or both eyes, and is chiefly seen in the dog. The opacity is first seen at the inferior two-thirds of the posterior surface of the cornea, and after a more or less lengthy period the inflammatory process extends to other structures, and ultimately sets up a glaucomatous condition, followed by chronic panophthalmitis and hydrophthalmos. *See* luxation of lens].

Suppurative Keratitis.

Ulceration of the Cornea.

As has been proved by Leber's experiments on animals, suppuration of the cornea cannot be produced in the absence of infection with the organisms causing suppuration. Whether this takes place by endogenous or exogenous infection, the final result is the same and ulceration of the cornea is produced. In order to better understand the course of the inflammatory phenomena, Leber's experiments of inoculating the layers of the cornea with the micro-organisms found in pus will be described. At first these organisms multiply and cause necrobiosis of the surrounding elements, the cellular

destruction being shown by the formation of opaque spots. Then the toxins becoming diffused through the cornea cause dilatation of the scleral and sub-conjunctival vessels, and the arrival of the leucocytes, which come to form an actual zone of defence, makes at the point of inoculation a whitish zone of infiltration becoming gradually more dense as the centre is approached. The point of necrobiosis increases from the number of leucocytes destroyed in the struggle with the pyogenic bacteria; to this enlarged point the name of *corneal abscess* is given, though it is not possible clinically to recognise the formation of an abscess. Soon, at the centre of the infiltration an exfoliation of the epithelium takes place and this constitutes an *ulcer*; the cornea suppurates.

The diffusion of toxins taking place not only in the corneal tissue but also in the depths on the side of the anterior chamber, the endothelium of the membrane of Descemet becomes detached round the border of the focus of necrosis, the fibrin of the aqueous humour is deposited at this point and forms a clot, which is soon penetrated by leucocytes, and these slipping to the bottom of the anterior chamber along the posterior face of the cornea constitute *hypopyon.*

The track of the pus going from the corneal ulcer to the hypopyon seems in some cases to be situated in the layers of the cornea although in reality it is always on the posterior face; this appearance was the condition described by old authors as *onyx*. Arrived at this stage the corneal affection is spoken of as *keratitis with hypopyon.* (Fig. 66). Such are the phases in the formation of a corneal ulcer—phases which are not necessarily passed through in every case of infection of the cornea. The course of the ulceration, once constituted, has now to be followed. If the necrosis continue its destructive work it may cause, on the surface or in the depth, what is termed a *progressive ulcer;* its walls become dull in appearance, its borders are slightly salient and are surrounded by a wide, dense, opaque zone. All these symptoms are due to the cellular infiltration of the layers of the cornea and so the condition is sometimes called *infiltrated*

ulcer. On the contrary *the ulcer is said to be regressive* if it tends to cicatrise; this is recognised by the walls becoming glistening and shining, and the zone of opaqueness surrounding it becoming restricted and clearer. In short, there is an absorption of the products of effusion—hence the name of *detergent* or *clean ulcer*. From this time the ulcer seems to gradually fill up; this is the stage of *cicatrisation*, which is usually accompanied by the development on the surface of the cornea of long flexuous vessels united like the hairs of a brush, redder than those of pannus, one end being in the ulcer, the other becoming lost beyond the sclero-corneal limbus.

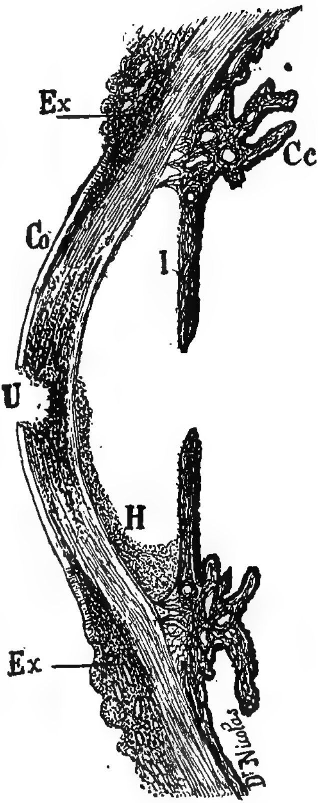


Fig. 66.—Keratitis with hypopyon. Experimental ulcer on the cornea of the rabbit.

cc, Ciliary body. *co*, Cornea. *Ex*. Subconjunctival, pericorneal infiltration and vascularisation. *h*, Hypopyon. *i*, Iris. *u*, Ulcer with cellular infiltration of the layers of the cornea.

Cicatrisation always takes place by means of an opaque tissue on a level with the corneal stroma; the epithelial layer is entirely regenerated by proliferation of its margins, and in the end it completely covers the newly formed tissue. If the loss of tissue has been entirely filled up the cicatrix is on a level with the rest of the cornea, but it can be recognised by its opacity

and the inequalities on its surface. If, on the other hand, the lost substance has not been completely replaced, a flat facetted scar is left which breaks the regularity of the curvature of the cornea. Lastly it may happen that the tissue of the cicatrix being less resistant than the other parts of the cornea allows itself to become pressed outwards by the intra-ocular pressure and then the scar will be salient and stands out on the cornea—this is called an *ectasic cicatrix.*

The consequences of the corneal ulcer progressing must now be considered. Extending its course into the depths the ulcer may destroy the whole thickness of the cornea, and a time comes when the membrane of Descemet is the only separation between the aqueous humour and the exterior. Under these conditions it either resists or, more probably, yields and forms a hernia through the ulceration—this is called *keratocele.* What usually happens is that the membrane gives way under the intra-ocular pressure and this may cause several conditions which will be considered later. As long as a few layers of the cornea are left the bottom of the ulcer remains opaque: when the membrane of Descemet is the only floor to the ulcer, the edges are opaque but the floor is absolutely transparent. In one case observed in a horse there was a wound, with loss of substance of the cornea extending to the membrane of Descemet (and consecutive infiltration of the margins of the wound) and this was laid bare over a circular area of about 2–3 mm. diameter; here the depth was quite transparent and resembled a plate of mica. In the horse, in which this membrane is thick and resistant, there is little cause to fear keratocele, but it has been observed in the ox and dog. [It is quite common in the latter animal, without perforation. In many cases there may be little secondary inflammatory reaction, and under such conditions reparation is often slow].

Perforation of the Cornea. Rupture of the membrane of Descemet is followed by an escape of the aqueous humour (which causes a loss of tonus in the eye), and the projection

of the iris and lens against the posterior face of the cornea. In fact the anterior chamber no longer exists as a chamber.

(*a*) *The Perforation takes place in front of the Iris.* This membrane obstructs the opening and allows the chamber to be re-formed by the re-accumulation of the aqueous humour.

But in proportion as the anterior chamber is refilled, it tends to again place the internal structures of the eye into their original positions; the iris, which remains fastened to the cornea, is stretched and the pupil is deformed. In a case in which the perforation of the cornea is a small one the iris is not caught in the opening, and as long as the cicatrisation of the cornea takes place without the iris taking an active part it remains attached to the back of the cornea more or less intimately, and this is known as an *anterior synechia.* In the contrary case in which the corneal opening is large, the iris is engaged and may even protrude outside the orifice; this constitutes a *hernia of the iris* (Fig. 67). When the cicatrisation of the cornea takes place by means of the iris and an exudate, the condition is known as a *corneal staphyloma.*

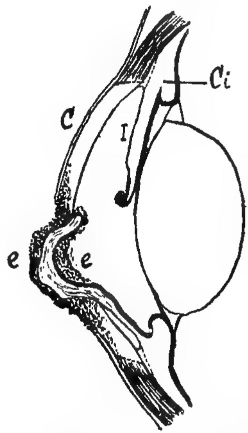


Fig. 67.—Perforation of the cornea with hernia of the iris (partly after Fuchs). The herniated part is the iris (tumefied); its two faces are covered by an exudate *e e*. Definitive cicatrisation constitutes staphyloma.

(*b*) *The perforation takes place over the pupil.* In this case, the iris not obstructing the opening of the perforation, the aqueous humour constantly flows from the anterior chamber, which is only re-established after cicatrisation of the corneal fissure by proliferation of its margins. Emmel reports a case of corneal fistula which took a fortnight to close.

The fistula may, as soon as it is formed, be closed by the anterior face of the lens, which in consequence sustains a

circular central opacity—this is one of the causes of *anterior polar cataract.*

Complications of Perforations of the Cornea. These are almost always the result of loss of intra-ocular pressure (except in cases of infection of the eye); luxation of the lens—this, in man, [dog and cat], has been seen to be protruded outside the eye; intra-ocular hæmorrhages; detachment of the retina.

Etiology. The infection which produces the corneal ulcer may be endogenous, and takes place by the blood vessels as far as the cornea and then by the lymphatic vessels in its interior. Or it may be exogenous, and then it is contemporaneous with an injury or consecutive to an already existing wound, so that every abrasion of the cornea is not a corneal ulcer from the first. Epithelial desquamations and superficial wounds following on traumatisms, for example, are simple wounds which heal without causing the least defect of the cornea, but deeper wounds lead to a reaction, which is betrayed by an acute infiltration of their margins and they thus become easily infected.

Predisposing causes. Certain general conditions diminishing the powers of resistance of the animal against the organism seem to play a predisposing part. The corneal ulcerations observed in diabetes mellitus in the dog (Fröhner), and even in the horse (Heiss), go to support this view. In the ulcerations seen in distemper in young dogs it is more difficult to blame weakness due to the disease itself. In any case this debility cannot be regarded as a sufficient cause of the affection, as had been remarked by Cadiot.

But the infection may find local conditions favourable for its development. Epithelial exfoliations, wounds, burns, etc., have already been mentioned. Dupuis saw cases of ulceration of the cornea occurring in horses from oil of tar being rubbed on their halter ropes; the affection disappeared when the halters were cleaned. From experiments by Leber, Eberth, Stromeyer, and Fritsch, it seems that when the cornea is not well-protected by the eyelids a keratitis is produced by desiccation, and that then the slightest exfoliation of the cornea

becomes infected and ends in ulceration. Lastly, Müller considers that certain breeds of dogs, pugs for example, are particularly subject to the condition on account of the exophthalmos which is characteristic of the breed exposing the eye to injury.

Endogenous infection. Apart from eruptive diseases, it seems that the ulcers of the cornea met with in the horse in influenza (Schindelka, Könhauser), and in dourine (Schneider and Buffard), must be attributed to endogenous infection; also in the dog in distemper (Leblanc, Boucheron, Cadiot, Mouquet); and in the last stage of experimental nagana in a great number of animals. Hess and Guillebeau have noticed the condition in the cow during the course of an attack of streptococcic mammitis.

Cadéac has seen ulcerative keratitis run an enzoötic course in sporting dogs, especially in marshy districts. Local lesions are preceded by serious general disturbances, both being doubtless determined by piroplasmosis. (*Journal de Méd. Vétérin. et de Zootechnie, 1910*).

Exogenous infection. The methods of infection here are various. Suppuration of the conjunctiva alone is capable of determining the breaking down of the cornea by maceration of the epithelium and the consecutive infection. This commonly happens in the epizoötic keratitis in cattle which will be discussed later. Schischkowiski has described an infectious purulent conjunctivitis of bovines which attacked two horses, and was complicated by ulceration of the cornea and perforation. Delmer, in an epizoöty of muco-purulent conjunctivitis in the goat, saw animals suffering from ulcerations of the cornea which narrowly escaped causing perforation. In gonorrhœal ophthalmia in man, the very irritant action of the pus (from the conjunctivitis) on the cornea, in acute cases, causes ulceration.

Suppuration in the lacrimal passages leads to the same result in man. Examples have been seen in birds in which the nasal secretion, as well as the pseudo-diphtheritic conjunctival secretions has caused ulcerations on the cornea, the depths

being covered by a dry scab, under which the ulceration continues until it quickly ends in perforation and panophthalmitis (Larcher, Kampmann, Hirschbrusch and Lang, Zniniewicz). Hebrant and Hermans have reported it as occurring in the dog as a complication of atrophic rhinitis with oezena (*Annales de Med. Vét. 1908*).

Accidental inoculations of all kinds, glanderous in the horse, tuberculous in the ox and pig (Richter), and pyogenic in all animals, may cause ulceration of the cornea with or without hypopyon. In man keratitis with hypopyon is still called "reaper's or harvester's keratitis" in consequence of its being so commonly found in labourers working in the fields in summer. Here the direct cause, as a rule, is a wound by a piece of straw, or a barley glume, etc. Although the fact has not been established in the domesticated animals, it may be mentioned as a probable cause in the etiology of infectious keratitis in cattle.

Experimental keratitis. Three cases of keratitis with hypopyon and anterior capsular cataract having been seen in man due to stings from bees or wasps, Huwald reproduced the condition in rabbits. He observed an intense kerato-iritis with hypopyon, cloudiness of the cornea, and capsular cataract, and two or three weeks elapsed before recovery took place (Morax).

Prognosis. Ulceration of the cornea is a serious affection demanding immediate and skilful attention. When it is not followed by perforation and panophthalmitis it always leaves corneal opacities which interfere with the power of vision to a considerable extent, this extent varying according to the position of the opacity. Lastly, in appreciating the gravity of the condition possible complications of the iris have always to be taken into account; synechiæ, pupillary membrane, etc. [Some varieties, especially Pekingese and other prominent eyed dogs, are liable to repeated recurrences].

Treatment. From this point of view ulceration of the cornea may be divided into primary and secondary; it is primary if it is the only lesion of the eye; it is secondary if

it is co-existent with a suppuration of the eye, conjunctival or lacrimal, of which it will almost certainly be a sequel.

A *secondary ulcer* needs, as well as the treatment given for primary ulcer, the treatment of purulent or catarrhal conjunctivitis or of suppuration of the lacrimal passages—in short, the treatment of the cause. In the case of conjunctivitis, as far as possible the use of metallic collyria should be avoided. If it is necessary to use nitrate of silver, sulphate of zinc, etc., these agents should be applied by means of a camel hair brush, so that they cannot irritate the ulcer.

The treatment of *primary ulcer* consists first of all in the frequent use of antiseptic irrigations, repeated three or four times daily in order to remove the products of the secretion; then the instillation of the same antiseptics between the eyelids. A 1 : 4000 solution of sublimate may be used, or cyanide of mercury 1 : 2000; potassium permanganate, 1 : 4000; creolin, 1 : 100; hydrogen peroxide solution diluted with 1–2 parts of water; [chinosol, 1 : 2000; hydrarg. biniod, 1 : 4000]. In any case a collyrium containing a mixture of atropine and cocaine should be used, 5–10 centigrammes of each to 10 grammes of boiled distilled water; this should have a favourable action in soothing the pain, lessening the photophobia, at the same time reducing congestion of the iris and preventing complications of this membrane.

If the ulcer is "clean" (détergé) insufflations of calomel, or friction with stimulating ointments may be tried; red or yellow oxide of mercury 1 % or 2 % in vaseline. A piece of the ointment the size of a pea is introduced into the eye between the eyelids by means of a director, then the eyelids are brought together and lightly rubbed from outside. If cicatrisation occurs with the formation of exuberant granulations occasional applications of a pencil of silver nitrate will subdue the granulations.

When the ulcer is progressive antiseptic ointments may be employed to prevent it spreading: iodoform 2% or 3% in vaseline; aristol 5%. To these may be added insufflations of iodoform, and boracic acid, but these agents must be almost

impalpably amorphous. In dogs, especially in pet and house-dogs, besides the above mentioned treatment, it may be well to use in conjunction warm compresses of boracic solution or a decoction of chamomile flowers applied for half an hour two or three times daily.

If these measures are not successful in man, cauterisation, curetting and paracentesis are tried. Cauterisation of the margins of the ulcers is effected by means of the actual cautery after instilling cocaine or administering chloroform. In animals, in which local anæsthesia is advisable, there may perhaps be danger of perforation—the movements of the subject being difficult to prevent—in practising cauterisation of the ulcer. [The progress of the ulcer is often checked by the careful application of pure carbolic acid or 10 per cent. solution of zinc chloride].

Palpebral cauterisation in non-penetrating points is without danger, and may cause a favourable termination (Hann).

Nicolas considers curetting to be best suited to the exigencies of veterinary practice. If done with a small Volkmann's curette after the application of cocaine, there seems to be little danger; it is very efficacious in cleaning the ulcer and arresting its course.

Lastly, there have been cases in which the ulcer commenced to undergo repair immediately after paracentesis of the cornea was performed and evacuation of the aqueous humour obtained, such cases eventually ending in recovery. Observations have shown that this is an operation which is easy and which may be performed on animals without danger of infection if proper precautions are taken. Complications of corneal ulcers require interventions which vary with each case.

[Gray's experience in the treatment of various forms of corneal ulceration in the cat and in the dog is that nearly every case will recover without any heroic methods, such as caustics, the actual cautery, curetting, etc., being adopted. Macqueen's experience is identical. Mild and warm antiseptic solutions and, if any pain be evidenced by dread

of light or closure of the eyelids, cocaine, novocain, stovaine, or alypin and atropine or eserine instillations as the case may demand are all that are necessary, at least, in the earlier stages. Should the ulcers eventually become sluggish in undergoing repair, Pagenstecker's ointment (ungt. hydrarg. oxid. flav,) or common salt, will generally bring them to a successful termination.

On no account should nitrate of silver or lead solutions be used, as they are liable to leave deposits in the depth of the ulceration and a permanent blemish remains. Macqueen does not, however, agree with the view that silver nitrate leaves a deposit. Caustics, the actual cautery, and curetting destroy or remove normal living tissue which cannot, as a rule, be replaced by proliferation, and consequently a cicatrix is left.

When iodides are being given internally, calomel, mercurial ointment, Pagenstecker's ointment and other mercurial pre-preparation, excepting biniodide of mercury, should not be applied; they enter into combination on the surface of the eye, and thus set up irritation and conjunctivitis].

If *keratocele* is produced the animal should be placed in a condition of absolute rest, and then pressure should be applied to the keratocele by means of a compress applied outside the closed eyelids. Perforation is then less likely to occur. If the keratocele is too prominent it should be punctured, to cause a retraction of the membrane of Descemet and to allow the edges of the ulcer to come together.

In a case of *perforation* it is necessary to try to prevent the formation of an anterior synechia and to obtain as flat a cicatrix as possible. If the perforation is small and there is no hernia of the iris it may be treated by atropine, rest, and compression. Atropine instilled several times daily may completely detach the iris or reduce the synechia to a filament which will be no hindrance to the movement of the pupil. If the perforation is a large one, recent, and accompanied by a hernia of the iris, the herniated part should, as soon as possible be drawn out and excised (after having

detached the iris from the margin of the ulcer by means of a probe) and cut off on a level with the cornea. Treatment is then as in the preceding case. The hernia of the iris may also be reduced by means of the blunt end of the probe (Mouquet, Drouet); but this is not without danger of consecutive infection of the whole eye.

Lastly, if the hernia is of some standing and consequently the iris is too adherent to the borders of the ulcer, or even if the perforation is too large, the return of the iris intact into the anterior chamber should not be attempted. An attempt should be made to obtain as flat and solid a cicatrix as possible, by means of pressure by dressings if there is still suppuration, or by *suture of the eyelids* in the contrary case.

Corneal fistula necessitates the curetting of the margins of the ulcer and the instillation of collyria containing eserine and pilocarpine, with a compress to close the eye as before.

Epizoötic Keratitis in Cattle. This affection, which is intentionally included under ulcerations of the cornea, is worthy of some notice.

It has often been noticed by veterinary surgeons, by whom it has been called acute infectious keratitis (Möller), contagious keratitis (Frank Billings), enzoötic or epidemic keratitis (Cox), etc., according to its gravity and the idea which it gave as to its origin and development. It may be mentioned that confusion is often likely to arise, as keratitis includes almost all the ocular pathology of the ox. The term epizoötic contagious or infectious ophthalmia of cattle, employed concurrently with that of keratitis, shows that the diagnosis is often vague.

Bayer, who has a wide knowledge of ophthalmology, states that in Istria, where he has studied infectious ophthalmia in cattle, it presents itself in the form of a purulent conjunctivitis; sometimes, and more frequently, as a keratitis; lastly, in some cases in certain animals, as an irido-choroiditis. In an epizoötic of ophthalmia in bovines, Holcombe saw the affection start as a conjunctivitis, which on the third day became

first of all complicated with cloudiness of the centre of the cornea and then with ulcerations.

Judging from the symptomatology it seems likely that a number of cases of epizoötic or infectious keratitis are really cases of purulent conjunctivitis which have sometimes caused corneal ulcerations with their usual sequelæ. Or possibly irido-cyclitis, which is not rare in cattle.

Symptoms. Whatever may be the cause, most descriptions agree in stating that the trouble commences with a central circumscribed or oval opacity, at first white, then becoming yellowish, and at the same time the zone of peripheral infiltration increases and becomes more opaque. Soon a desquamation occurs at the centre of the opacity, and the ulceration asserts itself more and more.

The local reactionary symptoms are sometimes so intense that they alone attract attention. At first there is some lacrimation, and this is soon followed by a more or less abundant discharge of muco-purulent or purely purulent material from the internal angle. The eyelids are swollen and closed. The conjunctiva is œdematous, and sometimes forms a ring around the cornea; it is congested and suppurates, and may assume the tint of bright copper (Billings). Some large flexuous vessels start from the limbus and traverse the whole of the cornea, to end in the central lesion. To this conjunctival and superficial infection is sometimes added a circumcorneal red ring consisting of short, fine scleral or parenchymatous vessels.

True reactionary symptoms usually complete the semiology. The animal droops its head as if to ease the pain, its appetite is capricious or lost entirely, and if young there is often a rise of temperature.

Terminations. The infiltration may not proceed as far as ulceration; there may be resorption, and the cornea may more or less re-assume its transparency.

The ulcer will begin to cicatrise; but if left to itself the newly-formed tissue sometimes gives rise to the production of a small fleshy granulation which may sooner or later come

to be regarded as a corneal tumour. Schiet has seen actual callosities which resisted scratching with the finger nails.

Hypopyon has attracted least attention from most observers, but it has been noticed by Bayer, Camuset, and Schmid.

When ulceration progresses it tends to produce keratocele (Beresow) and perforation with all its sequelæ.

The minimum duration of the affection is from two to four weeks (Müller).

Pathological anatomy. In spite of a fairly large number of observations scarcely anything is known of the pathology of this affection. Professor Czokor, on examining specimens furnished him by Bayer, found an infiltration of leucocytes massed together or scattered through the tissue proper of the cornea. Further, the sections examined were interspersed with bacilli, some long and few in number, others short and more numerous, but the nature of these organisms he did not determine. The last named variety were particularly abundant in the vicinity of the membrane of Descemet, which was literally crammed with them.

Etiology. This affection is generally seen in ruminants and particularly in the ox, in which animal it had already been observed at the end of the eighteenth century by Huzard and Coquet [and even centuries before by various writers]. It has also been seen in the sheep (Ripiquet, Ackermann), in the goat (Mathieu, Bassi), in the mouflon and wild goat (Bassi). Amongst other species the horse is mentioned but rarely (Blazekowic, Beresow, Nordman, MacMullen) the pig (Mathieu). Young cattle are most commonly attacked (Cox, Scholz).

It is most common in summer (Lafossę of Toulouse, Brusasco, Cox, [R. Hughes]), and then in animals at pasture. It has been seen in winter in the Agenais (Guittard).

Its enzoötic or epizoötic character has attracted the attention of all observers. According to Müller, Beresow saw, in in the space of six weeks, 104 head of cattle attacked out of a herd of 478, about 20 per cent.; Funfstück examined 50 animals suffering from the disease in a few days, out of a herd

of 300 head, about 17 per cent.; Reischig counted 60 cases in 150 animals, 30 per cent. The disease presents the same epizoötic characters in the New World as in the Old; in the United States it has for a long time been recognised in Nebraska (Billings), and more recently in the State of Montana. [It was a common affection during the South African war (Smith)]. Though it has been met with in all parts of Europe it seems to be more common in Russia, in Austria-Hungary, and in Germany, than in the other countries. In France, Guittard, Thierry, Perussel, and Griveaud have reported epizoötics during the last few years. [Richard Hughes of Oswestry, and many others, have met with it in epizoötics in cattle and sheep in England].

The facility with which keratitis in bovines extends to a great number of animals at the same time has led the condition to be considered as infectious and contagious. The infection results from the ulcerative and purulent character of the lesions, and cannot be doubted; due to micro-organisms described by Blazekowic, Czokor, and Billings; it has on the other hand been attributed to parasites of the genus *distomum* by Willach. As for contagion it is far from being proved. Experimental work has given rise to divergent opinions: whilst Blazekowic claims to have discovered a micro-organism resembling the bacillus of malignant œdema of Koch, and to have successfully inoculated it to the horse, dog and cat, Billings after scarification of the cornea, Künstliche, Bayer, and Nocard, using the tears and pus placed on the surface of the cornea and conjunctiva (Guittard), have not been able to transmit the disease. Ackermann, Marder and Weese, from their observations consider the affection as contagious, though Angerstein could never show this character. A fact which seems best to prove this point is that horses exposed to risks of contagion are not, as a rule, affected; nor are men in charge of animals suffering from the disease.

It may be well to remark that it is not necessary to blame contagion as the cause of the affection spreading. Knowing the conditions under which "reaper's keratitis" develops in

the human subject it may be asked whether the same is not true for animals. Camuset, Fromaget, and Dor have already admitted the similarity in the symptoms of the two affections and do not deny that they may have the same cause. When a great number of animals are attacked it is possibly because they are exposed to the same risks and are under the same conditions of existence. The frequency of the occurrence of the disease in the summer months, and especially those of July, August, and September when the cattle are at pasture on stubble, in woods or land scattered with brushwood, etc.—in other words, under the most favourable conditions for receiving wounds of the cornea—seems to give colour to this theory. Further, the fact that the horse is rarely affected although the cornea is not refractory to infection, seems compatible with the fact that the horse is not exposed to the same risks as commonly as cattle or sheep. The presence in the cornea of the beard of wheat or the epicarp of any cereal would have great weight in the support of this etiology, although foreign bodies are not recognised in every case of "reaper's keratitis."

In concluding this chapter on etiology, it may be mentioned that Linter attributes epizoötic keratitis in cattle to a caterpillar (*Cnethocampa processionea*) which lives in great numbers on the oak and other trees, and he thinks that the beasts rubbing against the trees cause them to fall. He supports this theory by stating that the disease does not affect animals in sheds nor in years in which the caterpillars are not plentiful.

It is a fact well established by clinical and anatomo-pathological examinations in man (Pagenstecker, 1883), and in rabbits by experiments (Krüger and Becker) that the hairs of the caterpillar, and even of plants, cause on the conjunctiva and cornea a pseudo-tubercular nodular inflammation to which Sæmisch has given the name of *Ophthalmia nodosa*. The presence of the hair gives rise to a violent inflammatory reaction, and then produces a small nodule 1–2 mm. in diameter, usually hidden by the congestion of the conjunctiva. On the cornea a little opacity develops with quite clear borders,

in the middle of which, at its commencement, the presence of the hairs can be recognised with a lens; this does not suppurate. In man these superficial nodular lesions are accompanied by similar productions on the iris with exudation and the formation of synechiæ, etc.—experiments on rabbits have not caused these lesions of the iris.

As can be seen, these well established facts are in opposition to Linder's theory, as ophthalmia nodosa in no way resembles the keratitis of bovines just described.

Prognosis. Epizoötic keratitis of cattle is always a very grave condition, as it often affects both eyes, and its complications almost always affect the power of vision. It caused blindness in 80 per cent. of Reischig's cases, in 5–10 per cent. of Stéphano's.

Treatment. This should be the same as that described for ulceration of the cornea. Although contagion has not been proved it would be well to isolate healthy animals.

Keratitis with formation of Vesicles. Eruptive diseases may be accompanied by the development of small vesicles, aphthæ or pustules on the cornea which are in every way similar to the cutaneous or mucous eruptions characteristic of these diseases. Thus it is that Nocard and Leclainche have seen the lesions of aphthous fever, and the pustules of sheep-pox which may progress till the cornea is perforated and the eye is lost by suppuration. The eruption of horse-pox has been observed by Labat in the horse, that of variola in the ox by Jewsejenko, and in the sheep by Röll. In distemper Boucheron has seen phlyctenulæ, and bullæ which could be attributed to nothing else but the general infection.

Symptoms. The eruption is surrounded by a circle of infiltration and accompanied by intense photophobia, lacrimation, and a muco-purulent secretion when the vesicle bursts and forms an ulcer. Diagnosis is facilitated in most cases by the contemporaneous appearance of a similar eruption on the conjunctiva and in the cutaneous or mucous predilection seats.

Treatment. The aim must be to prevent infection of the corneal ulcer. To this end antiseptic collyria and ointments should be applied from the beginning. If they can be applied, very warm lotions are recommended.

[**Fascicular Keratitis.**—This somewhat resembles phlyctenular keratitis, and is very frequently seen in the dog, especially those breeds having prominent eyes. It usually attacks one eye and then the other, but not often both at the same time. It is recurrent and may last for years, having more or less short or long periods of intermission.

It is characterised by a long, narrow, but dense, red band of superficial vessels, which run parallel to one another, extend into the cornea, and terminate in a grey infiltration or slight ulceration towards the centre of the cornea. The vessels lie in a depression formed by the advancing ulcer and are on a level or below the surface of the cornea.

Very often there are several of these infiltrated or opaque spots, which not rarely leave, after many recurrences, permanent opacities. Perforation is never observed, and when the disease has reached its height the vessels gradually begin to disappear and ultimately vanish, leaving slight nebulous opacities which never completely vanish. After repeated attacks, some fine long vessels as well as opaque spots permanently remain behind.

During the earlier stages of an attack the usual inflammatory reactional symptoms—pericorneal injection, dread of light, lacrimation, spasm of the eyelids, and rubbing of the eyes with the paw, are present.

Treatment. During the early inflammatory stage the use of atropine and cocaine in the form of an ointment, and applied several times a day, is indicated. When the acute symptoms have disappeared, calomel in powder, or the yellow oxide of mercury may be substituted. Special attention should be applied to the dietary of the animal, and almost constant exercise in the open advised].

Tubercular Keratitis. *Experimental form.* Tuberculosis of the eye in animals has not attracted the attention of veter-

inary surgeons to any extent except from a pathological point of view, and then the affection shows the characters of an invading tumour. More interested in the diagnosis of the different forms of keratitis in man (so difficult to classify in early stages), human ophthalmologists have resorted to experiments to determine the development and course of tubercular infection of the cornea. Hænsell, Panas, Kostenitsch, and Wolkow have furnished data which will not be without interest to observers specially interested in diseases of cattle.

Near the point of inoculation, about the eighth day an opalescence becomes visible, and towards this a tuft of small vessels is directed. It is soon possible with a lens to recognise in the middle of the inflamed area, some small white, grey, or yellowish points which are miliary tubercles. By becoming fused together these, about the twentieth day, give rise to a purulent infiltration which becomes ulcerated. At the same time the affection progressively radiates by the formation of new peripheral nodules and the congestion is increased. Repair commences towards the end of the first month—it is slow and is not complete until the end of the fourth month (Panas). In none of his experiments did Panas see the affection transmitted to other parts of the eye or to the system.

Glanderous Keratitis. This has been encountered in the horse suffering from glanders. Richter records such a case affecting the sclero-corneal limbus to the extent of 12 mm. by 5–7 mm. The patch was granular, greyish or purplish on its surface, and slightly raised above the contiguous parts. Small grey or yellowish grey nodules, of the size of a grain of semolina rice or of a pin's head, run their course in a day or two, leaving small erosions. Twelve hours after the injection of mallein the granulations became turgescent and of a bright red colour; the whole of the internal half of the eye was covered with a granular eruption; thirty-six hours after, the organ regained its former aspect. The bacteriological diagnosis was made by Professor Schütz (Richter—Ein Fall von Angenrotz beim Pferde. *Zeitschrift für Veterinärkunde*,

Band viii. p. 62, 1896. Quoted by Nocard and Leclainche, *Les Maladies Microbiennes des Animaux*, T. ii, p. 198, 1903).

Keratitis Neuroparalytica. Definition and experimental data: Magendie experimenting on animals found that section of the trigeminal nerve caused, amongst other symptoms, a keratitis, which he attributed to trophic disturbances. The cornea became cloudy and slightly inflamed. Then the epithelium became exfoliated from the centre towards the periphery, leading to the denudation of the whole extent of the cornea. Later the opacity increased and became yellow, with formation of hypopyon, and at last the cornea underwent purulent softening, to a greater or less extent, in its central region. In some cases, however, the inflammation ceased without leading to suppuration. The course of the affection is is slow. This form of keratitis is especially characterised by the absence of reactionary symptoms; there is no lacrimation, no pain and consequently no photophobia, although the nerve supply of the lacrimal gland and the ciliary nerves comes from the trigemimal, the first directly, the second through the intervention of the ophthalmic ganglion.

Nicolas saw this form of keratitis develop on a dog, the ciliary nerves of which he cut in an attempt to ligature the optic nerve. An extensive ulceration was produced with prolapse of the iris and panophthalmitis.

Spontaneous neuroparalytic keratitis. Rivolta observed this in a sheep following on an exophthalmos which led to the stretching of the ciliary nerves, and Bruckmüller in the horse consecutive to inflammation of the cerebellar peduncles in the neighbourhood of the origin of the fifth pair. [Gray has seen this disease affecting the right eye of a dog and causing atrophy of the temporal and masseter muscles of that side, due to a tumour arising from the root of the fifth pair; this case was reported by Lionel Stroud in *The Veterinary News.* In the *Journal of Comparative Pathology and Therapeutics* (1892), Vol. v. p. 67, Colonel Butler, A.V.C., mentions a case of facial paralysis with marked paraplegia and sloughing of the cornea in both eyes, most marked in the left. The right

eye was constantly being drawn directly inwards and then suddenly brought back to a central position, only to be again drawn gradually towards the inner canthus. This condition persisted till the animal was destroyed. On post-mortem examination small tumours of the choroid plexuses of both lateral ventricles and also on the lateral parts of the cerebellum were found, and are described by Col. Rutherford, A.V.C., on page 373-4 of the same volume as angiomata].

Keratitis from Lagophthalmos. Definition and experiments: Lagophthalmos (*lagos*, a hare—and *ophthalmos*—an eye), is the name applied to the condition when the eyelids (when occluded) do not completely cover the cornea. Feuer. in producing an artificial lagophthalmos in animals, caused a keratitis which soon extended to suppuration.

The portion of the cornea which is not protected *and that only*—and it is this which distinguishes the condition from the preceding one—becomes dry, opaque, and ends by ulcerating and causing iritis, hypopyon, and even panophthalmitis. This condition is an example of the great readiness with which a dry cornea becomes infected.

In man keratitis from lagophthalmos is observed in paralysis of the orbicularis, in cicatricial retraction of the upper eyelid, in certain very marked exophthalmos, etc. The presence of the third eyelid may account for the rarity of the condition in animals.

Traumatisms of the Cornea. *Foreign Bodies:* According to Cadiot and Almy, oat-flights are commonly observed in the cornea in bovines, and in dogs small shot are not rare. On the contrary, judging from published statistics, foreign bodies are quite rare in the horse. [Formerly, however, when overhead hay-racks were in use foreign bodies were relatively common].

Nicolas has only met with one such case. This was a small oat-flight fixed to the cornea by the whole extent of its edges, and forming on the swollen surface a slightly salient area.

Violet has found actual incrustations of lead due to the inconsiderate use of collyria containing salts of lead in spite of the cornea being ulcerated.

Symptoms. The pain or only the inconvenience is always very marked, and is shown by an intense photophobia and lacrimation. Foreign bodies, especially if recently introduced into the eye, do not always cause an inflammatory reaction of the cornea, and consequently it is necessary, even in the absence of any infiltration which might attract attention, to make a careful examination of the cornea.

By looking at the cornea in various directions it is as a rule easy to recognise the presence of a foreign body and its incrustation, more or less deep, in the surface of the cornea. If it is superficial the accident is of a benign character; if situated deeply its removal may entail risking the perforation of the anterior chamber.

Treatment. The foreign body should be removed without delay [after complete anæsthesia of the cornea] by scratching with the blunt end of a probe or a small spud, if it is superficial. If it is deep it should be raised and enucleated by means of the point of a suture needle passed behind, and in a case in which this operation may push the foreign body further in, it is necessary to introduce at the periphery of the cornea a paracentesis needle, which by pushing the foreign body from behind forwards will allow it to be seized with forceps or removed in one of the above-mentioned ways.

Fig. 68. Scoop for foreign bodies in the cornea.

After-treatment consists in the instillation of atropine and cocaine, and the application of antiseptic ointments. When the foreign body is not removed at once, the cornea puts every possible means into play to try to remove it by suppuration, unless the body be aseptic—such as a small shot or a grain of powder—from some sort of firearm.

Solutions of Continuity. These arise from various causes, according to the habits of life of the animal: blows from a whip or twitch, blades of grasses in the large herbivora; scratches from the finger nails resulting from examinations of the conjunctiva; sword cuts or lance thrusts in troop horses;

[running against projecting rock or coal in coal mine horses;] bites in the horse and dog; scratches from the claws in dogs and cats, etc.

Superficial wounds and Epithelial erosions. Local reactionary symptoms, lacrimation, photophobia, acute pain shewn by resistance to examination on the part of the animal, attract attention. In order to recognise loss of substance it is necessary to examine the cornea from several different directions, as there may be no inflammation. The eroded part loses its polish and does not shine like the neighbouring portions; the margins can be distinguished slightly as having a shallow crenated edge. These slight wounds progress towards resolution without interference, and disappear in a few days. They are only serious when there is suppuration in the neighbourhood of the conjunctiva or lacrimal passages, as this may give rise to a corneal ulcer.

Treatment consists in the instillation of atropine and cocaine, and the application of antiseptic ointments or iodoform in the form of an amorphous powder.

Deep Wounds. (a) These involve the corneal stroma entirely, or in part, but *do not touch the membrane of Descemet*, and may or may not entail loss of substance.

In either case the margins of the wound swell from cellular infiltration and imbibition of tears, and become surrounded by an opaque zone, which is specially marked on the sloping parts. Here the curvature of the cornea may be altered from the density of the infiltration, sometimes in the form of an opaque keratectasia.

If the substance of the cornea is removed as far as the membrane of Descemet, this will close the bottom of the wound, and, as has been said, the transparency is not lost. Therapeutic intervention consists in the same measures as in the preceding case.

(b) The Membrane of Descemet is perforated. The symptoms are the same as those described in perforation of the cornea, and for treatment the same methods are applicable. [Gray has seen in the dog and cat good results from suturing the

cornea, after reducing the iris with or without excision of the projecting portion; very little opacity remained after the elapse of a few weeks.

Contusions of the Cornea. These are especially interesting on account of their possible complications: laceration of the iris, of the zonula of Zinn, luxation of the lens, detachment of the retina, etc. These will be considered under the head of contusions of the eyeball,

Burns and Corrosions of the Cornea. These result from accidental or intended action of caustic medications, lime, etc., or even of actual cauterisation. They are in man accompanied by opacities and the formation of a slough, the depth and extent of which it is difficult to ascertain; prognosis should on this account be guarded.

From experiments performed on the eyes of rabbits Gühmann has been able to determine three degrees of injury from the action of lime: (1) a nebulous opacity appearing a few minutes after contact, (2) a glassy opacity—giving the cornea the appearance of ground glass, (3) a porcelain-like opacity which is absolutely white. Gouvea has shewn that the slough contains particles of lime which allow a retrospective diagnosis to be made.

Corneal Opacities.

These are products of inflammation, or may be developed without inflammation.

Opacities non-inflammatory in origin. (*a*) As a *physiological condition* there exists in the horse a greyish circumcorneal opacity which has no ill effect on vision.

(*b*). *Opacities from Hypertony:* As as been mentioned, compression with the finger is sufficient to produce a slight cloudiness of the cornea. Now every pathological condition accompanied by hypertension gives rise to a generalised opacity of the cornea, sometimes very dense, bluish white or even dull white in colour, making the membrane look like eggshell. This opacity seems to be constituted by an œdema situated in the epithelial covering, and in fact if such

a cornea is pricked with a needle a transparent mark is left This fact can easily be observed in horses at the onset of certain cases of irido-cyclitis with hypertension. When this gives place to hypotension, the opacity clears up. To the same cause may be attributed the corneal opacities seen in hydrophthalmos, at least at the commencement, because in the later stages opacities of the stroma arise from chronic inflammation, and of the posterior face from fissuring of the membrane of Descemet. The corneæ of a cat which were deformed and disorganised by œdema shewed a silvery opacity, and Knape found on anatomical examination a destruction of the endothelium which he attributed to the infiltration of the membrane, thus agreeing with Leber's experiments. (*Archiv für vergl. Ophthalmologie*, No. 3, 1910, p. 330).

Opacities Inflammatory in origin. (*a*) Corneal cicatrices —Solution of continuity, ulcerations, and wounds, give rise to these. They are consequently very localised, and in animals present the peculiarity of becoming fairly completely resorbed (Möller), and in some cases there is complete restitution. Nicolas has several times seen in the horse cicatrices involving the whole thickness of the corneal stroma reduced to an insignificant superficial opacity; but he has not discovered how the transparent tissue is substituted for opaque tissue—a phenomenon which in human ophthalmology is considered impossible.

According to the increasing density of the opacity it is called a nebula, [macula], albugo, or leucoma. [*Nebula* is applied to slight opacities which are often only detected with lateral illumination. *Macula* indicates a denser opacity which can be seen in daylight. *Albugo* is an opacity which is translucent, and *Leucoma* is a permanent dense opaque non-translucent condition]. In its turn leucoma is said to be *adherent* if the cicatrix is attached to the iris, and *non-adherent* in the contrary case. In the former condition, resulting from a perforation of the cornea with hernia of the

iris, the cicatrix is always more or less impregnated with pigment and is consequently greyish in colour.

It can also be recognised by the existence of an anterior synechia which causes deformity of the pupil.

Leucoma may be either acquired or congenital. The latter has been recognised by Schulteiss in a dog in which the inferior half of the cornea was replaced by a true scleral tissue covered by the conjunctiva, and by Rückert in a pig in which there was an adherence of the iris, but without any inflammatory processes (adherent leucoma). Besides its lack of transparence the corneal cicatrix may cause a change in the curvature of the cornea and produce a facet or a projection.

(*b*). Opacity may result from the organisation of exudates or infiltrates, although the cornea has undergone no loss of substance, like those seen in non-suppurative keratitis, and particularly in interstitial keratitis, keratitis punctata profunda, and with pannus.

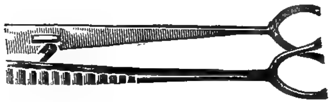
These opacities, distributed very irregularly in a diffuse manner, are partly resorbed, but less than the preceding variety, and cause more hindrance to vision for the following reasons; (*a*) Preventing light from entering the eye; (*b*) By producing the diffusion of the luminous rays, that is to say, an irregular refraction not allowing the formation of clear images. The consequences of corneal opacities recognised in man are: Strabismus, nystagmus, and myopia, though they have not been described in veterinary medicine. [Very often one encounters in the horse faint or nebulous linear opacities for which no well founded cause can be ascribed. They are frequently, but perhaps erroneously, considered to be the results of a lash from the whip.]

Treatment of Opacities of the Cornea. This includes clearing the opacity and getting rid of it entirely; creating an artificial means of access for the luminous rays; and lastly, masking the presence of the opacity.

Clearing the Opacity. As has been pointed out, much must be left to time. It may be assisted by the action of stimulants such as friction with mercurial ointment; red and

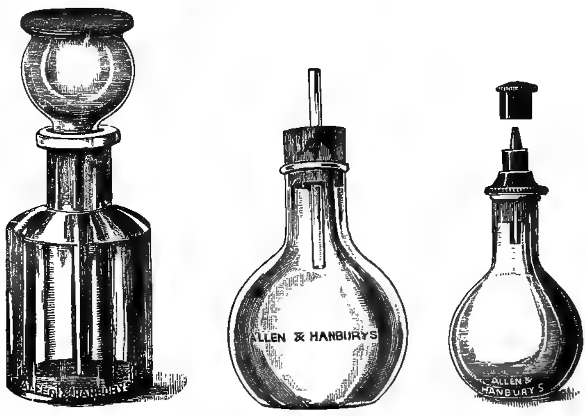
yellow oxide 3 or 4 per cent. in vaselin; insufflations of powdered calomel, or sugar, or a mixture of these agents in equal parts; sub-conjunctival injections of 5 : 1000 sublimate or 5 : 100 iodide of potassium.

Subconjunctival injections. Have the animal well under restraint. Instil a few drops of 4 per cent. solution of cocaine.



Fixation Forceps.

Fix the eyelids open by means of an eye speculum, or leave this to the care of an assistant. Seize a fold of the bulbar conjunctiva in the upper region by means of a pair of fixation forceps, and inject under this fold one or two cubic centimetres of the liquid. With a little practice it is easy to make

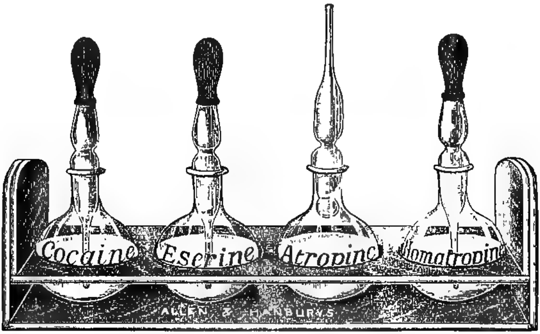


Eye Droppers.

the injection without the speculum and forceps, which have the disadvantage of more or less tearing or irritating the conjunctiva; the left hand lifts the upper eyelid and the right holds the syringe in such a manner that the needle touches

the cornea tangentially, and pricks the conjunctiva obliquely. The transparence of the membrane allows the needle to be seen penetrating the episcleral tissue, and the conjunctiva is raised by the injected fluid.

In pannus the clearing of the opacity is obtained by scarifying and by periotomy (*see* p. 195).



Eye drop Bottle Stand.

Optical iridectomy. This operation consists in making an artificial pupil in order to allow luminous rays to reach the retina. It is practised when the opacity is dense, central, and completely covers the pupillary field.

Tattooing the Cornea. This is purely a cosmetic artifice, practised to hide the disfigurement resulting from an opacity; it is more often applied to animals than optical iridectomy.

The operation has been performed by Bayer on the horse, by Möller and Schleich on the dog, and by Kotelmann on a vulture in the Zoological Gardens at Hamburg. [In the dog very often opacities become, after a time, obscured by deposits of melanin, and therefore do away with the necessity of this operation].

Fig. 69. Tattooing Needle.

It consists in pricking the cicatricial tissue with a guarded needle, and afterwards spreading Indian ink over the surface

so treated; it is preferable to use de Wecker's grooved needle, which carries the ink deeply into the cicatrix. To be successful the operation must be repeated several times. Cocaine should be instilled into the eye, and the tattooing instrument must be sterilised, as also must the ink.

[**Black Pigmentary Spots or Deposits.** These are commonly encountered in the dog and are the result of deposits of melanin in the substance of the cornea, or in cicatrices following on deep corneal ulceration; in parenchymatous keratitis and in pigmentary keratitis (*see* pp. 154, 161). They cannot be removed, and should therefore be left alone, as they are not very noticeable].

Ectasiæ of the Cornea.

According to their origin these are divided into ectasia of inflammatory origin, such as staphyloma and keratectasia; and ectasiæ of non-inflammatory origin—keratoconus and keratoglobus.

Staphyloma. Following on perforation of the cornea, this ectasia is consequently formed by the iris and cicatricial tissue (iridiæ staphyloma). It is always bluish and blackish in colour, due to iridial pigment. Staphyloma may be total when the sight is completely lost, or partial if vision is only embarrassed. Besides this essential inconvenience, staphyloma produces a deformity which is not negligible even in animals, for it may go so far as to interfere with the closure of the eyelids. Lastly, it is a source of irritation to the eye, and causes lacrimation, photophobia, and pain from the stretching of the iris.

Leblanc, May, Möller, and Mouquet have observed it in the dog, [in which animal it is a very common condition] and Ekc, Möller and Bayer in the horse. [It is occasionally seen in the cat].

Treatment in animals can only be preventive. In every case in which a perforation of the cornea is met with, the surgeon must direct his efforts towards obtaining as flat a cicatrix as possible by the means indicated (*see* p. 176). In

the presence of an established staphyloma the effect of *pressure* may be tried, and in cases in which this fails a flat cicatrix may be obtained after *excision*. Schmidt had good results from this method in a dog (Bayer).

Keratectasia. Staphyloma being an ectasia formed by an irido-corneal cicatrix, by keratectasia is meant that the cornea only is involved, becoming weakened at some point either from infiltration or from an ulcer which has not perforated its entire thickness.

Besides its breadth, which is evidently variable, the ectasia may involve the whole thickness or only the superficial layers of the cornea. In a horse which showed a flat, still recent cicatrix resulting from a wound (not perforating the cornea), Nicolas saw an ectasia of the superficial layers the size of a pea situated underneath the opaque cicatrix. It was produced by a serous infiltration; it changed its position and disappeared when the cicatrisation was complete. [This form is often seen in the dog].

Keratoconus, Conical cornea, Staphyloma Pellucidum. Definition and experiments. The cornea becomes conical from weakness of its centre and hypertension of the eye. This deformity leaves the cornea transparent and causes astigmatism; the membrane is sometimes cloudy. It is a rare condition in man and its pathogenic origin is unknown. [This condition is one in which the cornea becomes elongated in the form of a perfectly clear cone without any opacity or turbidity. It may attack one or both eyes, and is especially encountered in the griffon Bruxellois, British varieties of the Toy Spaniel and the Japanese and Pekingese Spaniels].

His, Panas, and Elschnig have tried to produce the condition in rabbits by the destruction of the membrane of Descemet by means of curved needles. They caused the formation of small opaque keratectasiæ in no way resembling a true keratoconus; these disappeared in a little while leaving no traces. It is only from confusion with staphyloma and keratectasia that some cases of spontaneous keratoconus have been reported in animals. [Gray, however, has seen it in the

dog as a spontaneous condition, as well as a conical condition of the cornea, appearing sometimes in the latter stages of vascular keratitis. This complication of vascular keratitis generally attacks both eyes and may be seen in any breed of dog. The vascular condition of the cornea frequently remains after the disappearance of the conical form.

Treatment. Gray found that by painting the apex of the cone, in uncomplicated cases of true conical cornea, with a 5 per cent. solution of nitrate of silver, a cloudiness was at first produced, but that when the painting was discontinued, the artificially produced cloudiness and the conical condition of the cornea soon disappeared. In the case of the complicated variety irritants should be avoided. Eserine, or cocaine and adrenaline may then be prescribed with advantage].

Keratoglobus. This name is applied to the condition in which there is an increase in the size of the whole cornea such as is seen in hydrophthalmos.

Tumours of the Cornea.

Having their origin in the cornea itself these are very rare, most tumours of this membrane being the result of secondary invasion. Dermoids are fairly frequently met with, but as they are almost always on the sclero-corneal limbus they have been mentioned under tumours of the conjunctiva. [Wooldridge mentions a case of carcinoma having its primary seat in the cornea, and after the eye was excised the lymphatic glands of the throat were affected].

Surgery of the Cornea.

Peritomy. The object of this operation is to suppress all vascular communication between the conjunctiva and the cornea, as for example, in pannus.

This result is obtained either by means of the cautery applied to the conjunctiva a little behind the corneal limbus, and parallel to it, or by the excision of a piece of the conjunctiva: raising the membrane by means of forceps, a portion of it is excised with blunt pointed scissors. The

piece removed should be crescentic in shape, about 4–5 mm. wide and of sufficient length to remove the base of the pannus.

In both cases the operation is performed after having put a blepharostat or eye speculum in position, and instilling a four per cent. solution of cocaine, or 1–2 cubic centimetres of this solution may be injected under the conjunctiva; this has the advantage of detaching the conjunctiva from

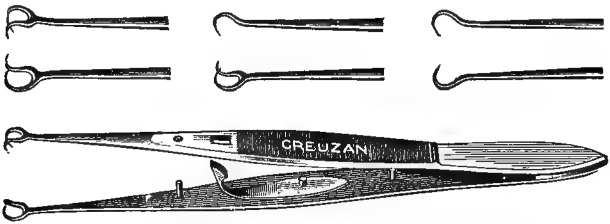


Fig. 70. Dr. Aubaret's fixation forceps.

the sclerotic, and consequently it is easier to take hold of the membrane to make the excision, also the anæsthesia is more complete.

Paracentesis. This small operation consists in puncturing the anterior chamber at the periphery of the cornea, in order to allow the escape of the aqueous humour or of pathological products which may be found in suspension. A few simple instruments are required: a fixation forceps (fig. 70), a para-

Fig. 71. Needle for paracentesis of the cornea.

centesis needle (fig. 71), and an eye speculum (fig. 72). These instruments should be of a size suitable for the eye to be operated on. As a general rule those used for man are suitable for dogs; for the horse they should be about double the size.

The eye being rendered insensitive, which can be recognised by the conjunctiva not being moved on pinching with

the forceps, the conjunctival culs-de-sac are well irrigated with a warm solution of boracic acid [or chinosol] and the eye speculum is inserted; the conjunctiva is then seized at a point opposite to that at which it is decided to puncture the cornea. Then the forceps are moved to shift the eye about till a suitable point for puncture is exposed. The paracentesis needle is then introduced very obliquely, parallel to the iris and in such a way that there is no chance of wounding either the iris or the lens. [In the horse, according

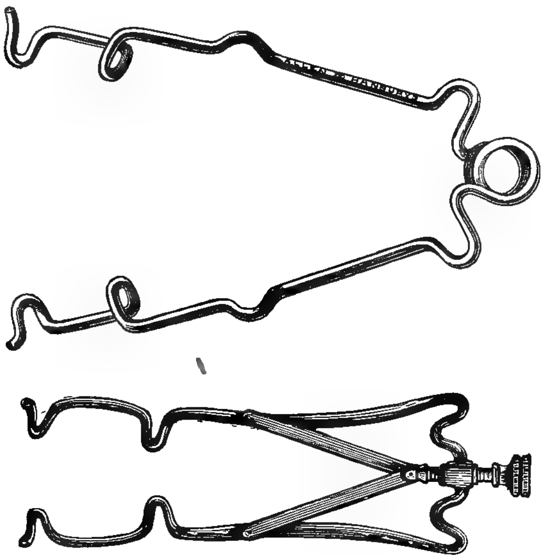


Fig. 72. Blepharostats or eye speculums.

to General Smith, who has had a somewhat extensive experience in this operation, both for filaria and also evacuating the anterior chamber to reduce tension in specific ophthalmia, the lower and outer margin of the cornea, not too close to the sclera, near the letter *h* in the right hand of Fig. 73, should be the seat of puncture in the case of the *left* eye. For the *right* eye the lower and nasal side, unless the operator

is ambidextrous]. As soon as the point has penetrated the anterior chamber, the aqueous humour, being under pressure, escapes with a rush, and the needle being withdrawn the operation is complete. [General Smith uses a fine lancet guarded with cotton wool, but no speculum, as it only excites resistance. The lower lid should be depressed with the hand, and this steadies the operation. As the cornea is very tough the knife should be very sharp and the puncture done boldly].

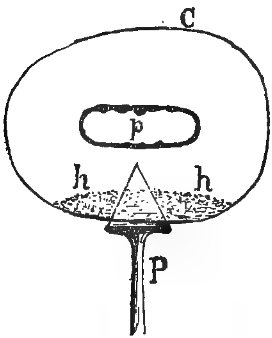


Fig. 73. Paracentesis of the cornea. *c*, cornea. *hh*, hypopyon. *p*, pupil. *P*, Paracentesis needle introduced.

If it is desired to remove hypopyon or any foreign body the incision is made larger by pushing the puncturing needle further into the chamber, so as to allow the foreign body to escape or else to permit the introduction of small forceps to seize it.

The choice of the seat of the operation is important. In the horse and in ruminants, in which the orbital arch is prominent and in which the cornea occupies almost the whole of the orbit, the eyeball cannot be fixed in front or behind, and consequently the paracentesis can easily be performed at either the temporal or nasal regions. In the dog it is possible to perform it at either of the four cardinal points.

The operation being finished, the edges of the wound, being bevelled, coapt of themseves and the risk of infection is very slight; however the eye should be protected for a few days by a compress. [The chamber refills in a day or two].

CHAPTER VII.

THE UVEAL TRACT.

Iris, Choroid, and Ciliary Body.

Anatomy and Physiology. The name *Uveal Tract* is given to the vascular and pigmentary membrane situated between the sclerotic and cornea on one hand and the retina on the other. If the sclerotic and cornea are removed without touching the subjacent structures the uveal tract, attached to the optic nerve, on account of its colour and shape, resembles a grape hanging from its pedicle—whence the name of uvea (*uva*=a grape).

This second covering of the eye, although forming a continuous membrane, has not the same structure throughout its whole extent. It is divided into three parts—the iris, ciliary body and choroid.

The Iris.

This is a circular diaphragm situated in front of the lens and pierced by an opening which is known as the pupil. On its external margin it is attached to the sclero-corneal region, in a manner to be described later, and on the other hand it is continuous with the ciliary body. The internal or pupillary margin is free but rests on the anterior face of the lens. In this position the iris is immovable; if its point of support against the lens is removed, as happens in luxation of the lens, the iris trembles with the movement of the eye (*iridodonesis*). The whole membrane of the iris is not entirely in a vertical plane, it is pushed slightly forwards by the lens. The space between the cornea and the lens is divided into two unequal parts by the iridial diaphragm. These compartments are known as the anterior and posterior chambers, they communicate by the pupil and enclose the

aqueous humour. The anterior chamber is the larger of the two and can be examined in all parts, but the posterior is hidden behind the iris.

The existence of the posterior chamber can be shown by forcing into the anterior chamber an injection of coloured gelatin. In a section of an eye so treated, the gelatin can be seen occupying the triangular space (the base being towards the periphery) between the iris in front, the ciliary body above, and the fibres of the zonula of Zinn and the lens behind.

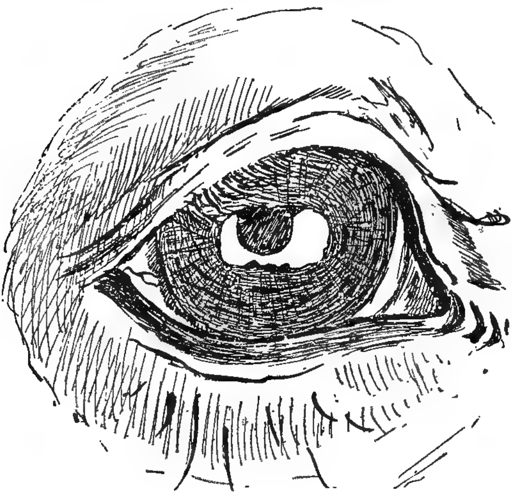


Fig. 74.—Corpora nigra of horse.

The anterior face of the iris has the appearance of being thrown into folds transversely, and of being striated vertically. Under physiological conditions its appearance is always glistening and its colouring varies according to the position and the species. The region bordering the margin of the pupil is often a little darker than the rest. On the remainder of the membrane narrow circular or interrupted bands, fairly regularly scattered, stand out like zebra or tiger markings on account of their darker colour. In the horse the colour of

the background is brownish yellow; yellow brown in bovines, bluish grey in the goat, brown or golden yellow in the dog, greenish in adult cats and clear blue in young kittens (Chauveau, Arloing, and Lesbre).

[This colouration varies very much in individuals of the same species. In many instances it has some relation with the colouring of the coat and skin. In piebald and skewbald horses pigment may be entirely absent or partially intersected with normal colouring. It is generally absent in the Hanoverian cream State horses.

In the Arkwright collie it generally has a variegated appearance due to absence of pigment in certain sections. In white dogs it is often bluish-grey in colour, and in the Siamese cat the colour is generally sky-blue, which may also be seen in one or both eyes of white cats. In cats in general the shade of the iris varies from amber to yellow or dark golden colour, and in many instances the pupillary circumference may be tinged with green. When the eye is of a greyish or greyish blue colour in the horse and dog the animal is said to be "wall eyed." In *birds* and *reptiles* all shades of colouration are found].

The posterior face is lined with a thick layer of brown or black pigment which turns round the margin of the pupil in places and forms a hernia which projects into the anterior chamber—the corpora nigra ([*corpus nigrum* Lindsay Johnson] Fr. *grains de suie*). These ectropiæ of the uvea, very rare in man, are the rule in the Herbivora. They are usually larger above than below, in the middle line rather than at the sides, and are almost always symmetrically placed in both eyes.

From examinations made by Lange the largest corpora nigra are found in the sheep, the smallest in the dog, in which animal they are sometimes absent. As a rule three or four can be counted in the horse above, and five or six below, exceptionally more (18 Schindelka), and up to 20 in sheep. [In the horse, although they are very well marked in the upper region and hardly noticeable in the lower, there are many exceptions to this, especially in ponies subsisting

principally upon food obtained in the open on mountain or moor, in which the lower corpora nigra are often very well developed, and almost, if not quite as large as those seen in the upper region.

In the *camel* and *llama* the two layers of the iris are well developed and form a series of prominences and depressions which interdigitate, the upper with the lower, when the pupil is in a state of miosis.

In the *hyrax* the appendages of the iris are still better developed, forming a highly contractile membrane called by G. Lindsay Johnson the *umbraculum*, as it shields the eye from glare. It seems to be under the control of will as it moves freely, independently of the amount of light falling upon the eye. In flat-fish such as skates a fringed process comes over the upper margin of the pupil and acts as a blind, which is capable of being drawn up or let down at will so as to regulate the admission of light].

Formed almost exclusively of pigment, supported by a conjunctivo-vascular network, the corpora nigra are sometimes hollowed out and the lacunæ are filled with fluid which gives them a cystic appearance (Gallenga). The greater circumference of the iris is continuous with the ciliary body, and is bound to the corneo-scleral region by the *ligamentum pectinatum*. The lesser circumference forms the pupillary opening. The pupil, most widely dilated in youth, at about the fifth or sixth year in the horse assumes an elliptical shape with the major axis horizontal, thus rendering ophthalmoscopic examination easy without using atropine; later it becomes narrowed and takes the form of a horizontal rectangle with rounded angles. Elliptical also in Ruminants, [in some birds], and in the pig, it is circular in the dog, [in elephants], and in a good many birds; it has the form of a vertical slit in the domestic cat. In all animals it is circular in a state of maximum dilatation. [In fishes and reptiles it may also be round or elliptical in the vertical or horizontal direction. In one class of fish it is quadrangular. It is slightly elliptical in a vertical direction in the fox and in some birds].

Structure. The iris is formed of a stroma covered on each surface by an epithelial layer. The stroma which forms almost the whole thickness of the membrane is made up of undulating, circular, oblique, and radiating connective tissue bundles, supporting pigment cells and numerous vessels directed, radially. Absence of the pigment cells gives the iris a leaden appearance—either general or localised—to which the term "wall-eyed" is applied. This lack of pigment sometimes coincides with general de-pigmentation of the eye [including the tapetum] when the eye is said to be an albinotic eye.

[The excised total albinotic eye when held up to the light is absolutely translucent].

On the posterior face of the stroma a continuous denser membrane is found, described until lately as the membrane of Brücke or Henle. Grinfeltt who has made a comparative study of this in a series of Mammals, calls it the dilating membrane, [musculus Brückei, musculus ciliaris, or tensor chorioideæ]. As a matter of fact it does not possess any of the properties of elastic tissue, but appears to constitute a variety of true unstriped muscular tissue, from which it only differs by its being fused into a continuous layer of contractile substance.

In the horse it is about 5 microns thick, while the stroma is ·42 mm., and extends over the whole length of the iris. This membrane is the dilator muscle of the iris, about which anatomists and physiologists have for so long been disputing.

Near the pupillary margin the muscular fibres which constitute the sphincter of the pupil are situated. Circular and absolutely free from any adherence with the periphery of the iris in animals with round pupils, they are in others, according to Eversbusch, attached to the periphery of the iris by a kind of inhibitory ligament which projects from the posterior face of the iris and is situated at the extremities of the major axis of the pupil. To this disposition which

renders the fibres of the sphincter immovable in two diametrically opposite points, Eversbusch attributes the elliptical shape of the pupil. (Fig. 75.)

In the horse the iris is thinner in the neighbourhood of the sphincter, being almost reduced to the thickness of the muscle only. Sometimes this contractile portion, a little deeper in colour, is separated from the rest of the iris by a furrow, visible in the living animal. The anterior face of the iris presents deep circular furrows scattered throughout its whole breadth in the horse and cat, and limited to the neighbourhood of the pupil in the dog (as in man). These are believed to represent actual absorbent openings (stomata). It is covered with a pavemental epithelium, continuous with that of the membrane of Descemet.

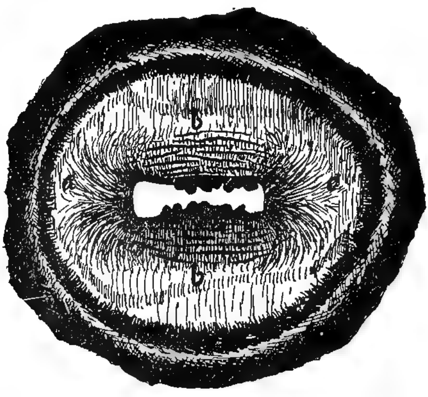


Fig. 75.—Iris of a sheep (after Eversbusch).

a, *a*, inhibitory or triangular ligament of the iris.
b, *b*, folds of contraction.

The posterior face is lined by a double row of epithelial cells which can only be well seen in sections made from the eyes of albinos. In pigmented eyes this covering forms a thick pigmentary layer (uvea), which becomes easily detached from the sections. Embryologically the uvea does not

belong to the iris: it is a continuation of the retina, whence its name, pars iridica retinæ. [In birds, the muscular fibres as those of the ciliary body belong to the striated variety].

Ciliary body. The ciliary body unites the iris to the choroid. It can only be seen after the removal of the posterior hemisphere of the eye. It then appears on its surface in the form of a pleated crown (godronnée) surrounding the lens; it is a little more deeply pigmented than the choroid. Its internal or concentric border is circular and forms a ring round the lens. Its external or excentric border is symmetrical in the horse and in Ruminants, the nasal side being flattened, and symmetrical in the dog and cat; it forms a finely denticulated line, which on this account was known as the ora serrata by the older anatomists. The pleated surface of the ciliary body is made up of a number of small pyramids placed one beside another in a radiating direction, their bases being towards the lens and apices towards the ora serrata; these are the ciliary processes. In a vertical section, the ciliary body has the form of a triangle, the posterior side of which is lined with a double row of epithelial cells of the same nature as those found on the posterior face of the iris, and consequently representing the ciliary part of the retina (pars ciliaris retinæ); the anterior side is attached to the sclerotic in a way which will be considered later; the base is continuous in one part only with the iris, the other part remaining free and projecting into the posterior chamber of the eye; the apex is lost in the choroid on a level with the ora serrata.

[According to Thomson Henderson* the ciliary region in the human eye extends from the ora serrata to the root of the iris in a zone of uniform breadth from 6–7 mm. This area is subdivided into a posterior and relatively smooth portion—the *orbiculus ciliaris*—and an anterior plicated region—the *corona radiata* formed by the presence of the ciliary processes. In the horse, cow, sheep, pig, cat and dog this same regular arrangement does not exist, for in them the ciliary processes

* *British Med. Journ.*, Nov. 4, 1911, p. 1169.

are not all of an equal size, nor is the orbiculus ciliaris of the same breadth in the various quadrants of the eye. In them the ciliary processes lying in the inner side are more numerous, though distinctly smaller, than elsewhere in the ciliary circumference, while at the same time the area of the orbiculus is here conspicuous by its absence. In the superior quadrant, however, are to be found the largest ciliary processes and the greatest extent of the orbiculus ciliaris. In the outer quadrant both processes and orbiculus tend to be smaller than above, while in the inferior quadrant there is still further tendency to diminution in the size of both. Thus, while in man the boundary line between the retina and ciliary region forms a circle with a serrated edge—the ora serrata—in the above-mentioned animals, this boundary has a clear cut edge, presenting a kind of oval outline, with a marked flattening on the inner side produced by the nerve elements of the retina coming here as far forward as the bases of the ciliary processes. The reason of this retinal prolongation is to be found, in the opinion of Henderson, in the necessity of these animals having a large and extensive field of vision on the outer side to protect their flanks. The same extensive perimetry is, of course, unnecessary in the rest of the field of vision, and therefore the breadth of the orbiculus is proportionately increased. The complete absence of the region of the orbiculus ciliaris on the inner side is a fact which certainly tells against Helmholtz's theory of accommodation. (Vide *Transactions of the Ophthalmological Society*, 1911). This author did not find any difference in the advancement of the retina towards the periphery in those animals having a horizontally or vertically elongated pupil].

Structure. The ciliary body is formed of a connective tissue stroma supporting a great number of vessels and some ramifying pigment cells. On its external or scleral face the muscular fibres which constitute the ciliary muscle are found. Remarkably developed in birds, in which they are composed of striated fibres, they are fairly well developed in man and in apes, in which it only contains smooth fibres or cellular

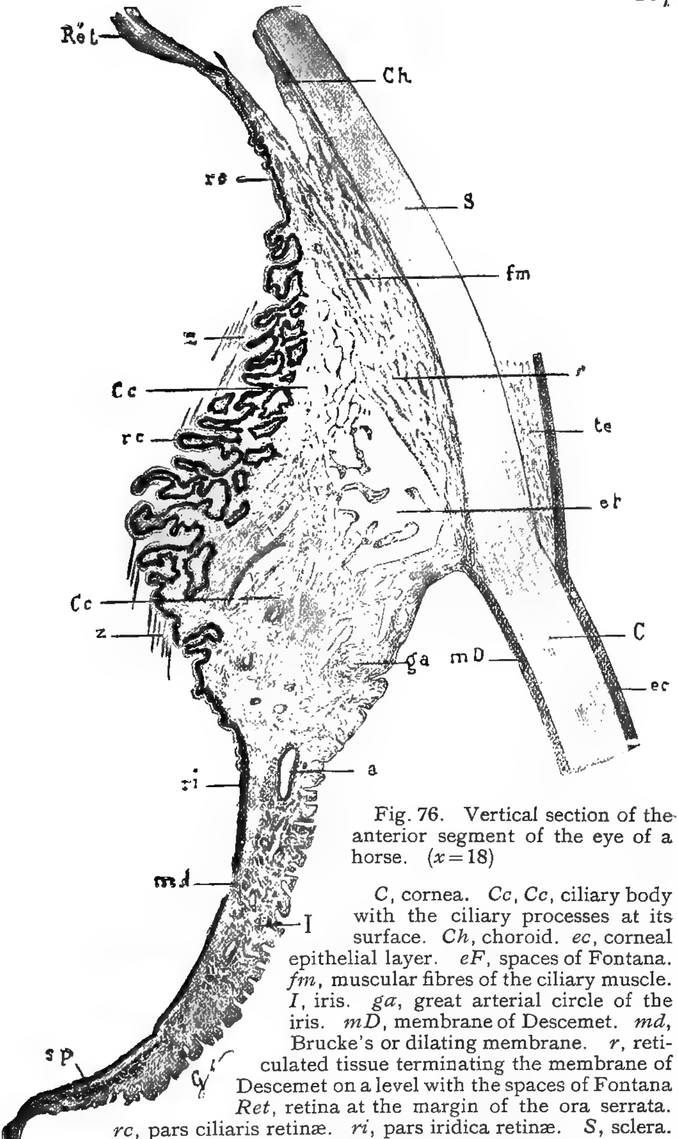


Fig. 76. Vertical section of the anterior segment of the eye of a horse. ($x = 18$)

C, cornea. *Cc*, *Cc*, ciliary body with the ciliary processes at its surface. *Ch*, choroid. *ec*, corneal epithelial layer. *eF*, spaces of Fontana. *fm*, muscular fibres of the ciliary muscle. *I*, iris. *ga*, great arterial circle of the iris. *mD*, membrane of Descemet. *md*, Brucke's or dilating membrane. *r*, reticulated tissue terminating the membrane of Descemet on a level with the spaces of Fontana *Ret*, retina at the margin of the ora serrata. *rc*, pars ciliaris retinæ. *ri*, pars iridica retinæ. *S*, sclera. *sp*, sphincter pupillæ. *tc*, episcleral or sub-conjunctival tissue. *V*, *V*, *V*, vessels of the ciliary body. *zz*, tract of the zonula of Zinn

fibres in other species. In the eye of the dog and cat it is much less developed, but it reaches its minimum in the eyes of a pig, horse, and in Ruminants, it which is sometimes hard to recognise. Würdinger found it more developed in wild Ruminants than in those living under domesticated conditions. The following table, resulting from his researches, will give an idea of the development of the muscle compared with the size of the eye. As has been done by Berlin, the development of the muscle may be compared with the size of the lens to gather some notion of the power of accommodation.

Species.	Sagittal diameter of the Eye.	Length of the Ciliary Muscle.	Maximum width of the Ciliary Muscle.
Ape ... mm.	16–18	2.5–2.9	.7–1.3
Dog ...	18	2.6	.4–.6
Cat ...	16–17	2.7–3.4	.27–.5
Llama ...	45	3.9–5.6	.64–1.1
Pig ...	18	2.5–3.2	.3–.4
Horse ...	45	2.7–4.3	.4–.5

Angle of the Anterior Chamber. Whilst in man the iris alone forms the posterior wall of the anterior chamber, in the horse and in most other species the aqueous humour also bathes the anterior face of the ciliary body, in consequence of the following arrangement. The iris and ciliary body of the horse form a dihedral angle with the cornea and sclerotic. On a level with its base the iris, as well as being continuous with the ciliary body, supports itself against the corneo-scleral region by columns or pillars which cross one another in such a way that they form meshes which become smaller as they approach the dihedral angle. (Fig. 76).

This system of pillars circumscribes cavities known as the spaces of Fontana, and the whole mass of the large pillars at the base constitutes the ligamentum pectinatum of Hueck, so called because, viewed from the side of the anterior chamber, these large pillars resemble from their alternating prominences and depressions the teeth of a comb. The membrane of Descemet sheathes the base of the pillars in the same way

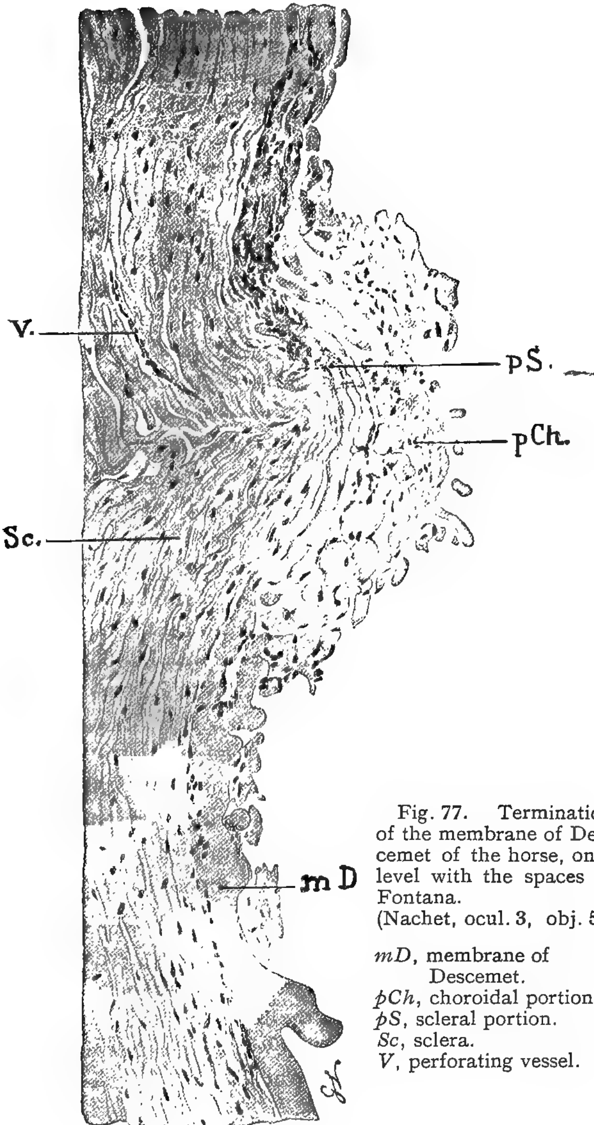


Fig. 77. Termination of the membrane of Descemet of the horse, on a level with the spaces of Fontana.
(Nachet, ocul. 3, obj. 5).

mD, membrane of Descemet.
pCh, choroidal portion.
pS, scleral portion.
Sc, sclera.
V, perforating vessel.

as its endothelium lines the spaces of Fontana. These spaces of Fontana seem to form a partitioned prolongation of of anterior chamber. If, on the other hand, the membrane of Descemet be followed to its superior limit, in a vertical section of the eye it can be seen to widen out, and (Fig. 77) to resolve itself into a great number of rounded, circular, or elongated divisions, or widenings, which are the sections of the ramifications of the membrane. These ramifications lined with endothelial cells form a reticulate, much divided tissue, one part of which is in contact with the sclerotic and becomes confounded with it (scleral portion); whilst the other juts out into the spaces of Fontana, spreads out like a fan towards the choroid, and goes to lose itself in the commencing part of this membrane (choroidal part).

The scleral portion forms the internal wall of the *canal of Schlemm;* Panas and Rochon-Duvigneaud who have studied it in man, and in the ox and pig, call it the sclero-corneal reticulum. The choroidal portion spreading out like a fan represents by its shape and situation the ciliary muscle of man, but in the horse it seems to have no muscular properties; it is only in its superior region bordering on the limit of the choroid and ciliary body that some thin bundles of muscular fibres, constituting the ciliary muscle, can be recognised (fig. 76).

The canal of Schlemm forms an excentric circle on the corneal margin. It is in communication with the aqueous humour on one hand and the episcleral lymphatic spaces on the other. Very much developed in birds, and quite apparent in man and in the carnivora, it is much less so in the herbivora. Its nature and function are still in dispute (fig. 78).

Choriod. The choroid lines the internal face of the sclerotic from the entry of the optic nerve to the ora serrata. Except in the region of the tapetum, which is of a beautiful azure blue tint (green or yellowish), the choroid is brown in colour, and on it can be traced towards the periphery the vortex of the ciliary vessels.

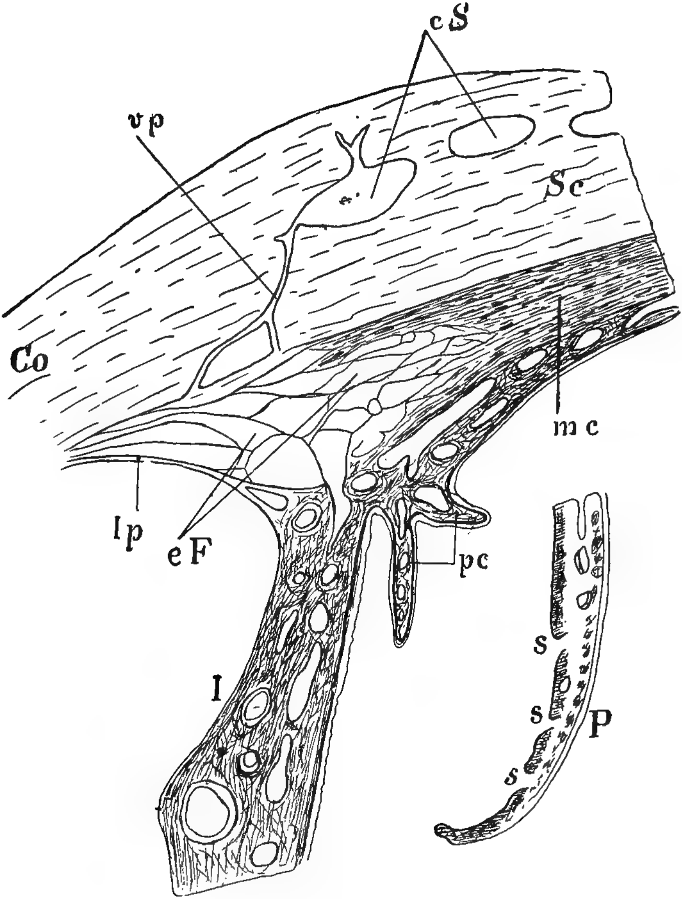


Fig. 78. Vertical section of the anterior segment of the eye of a dog. (After Nuel and Benoist).

Co, Cornea. *cS*, Canal of Schlemm. *eF*, Spaces of Fontana. *I*, Iris. *lp*, Ligamentum pectinatum. *mc*, Ciliary muscle. *P*, Pupillary portion of the iris. *pc*, Ciliary process. *s*, *s*, *s*, Stomata on anterior face of the iris. *Sc*, Sclerotic. *vp*, Perforating vessel which allows the spaces of Fontana to communicate with the canal of Schlemm.

Structure. The choroid is made up of four layers over most of its extent and five in the region of the tapetum; these are from within outwards, the vitreous layer, lamina vitrea, membrane of Brücke, or glassy membrane; the chorio-capillaris; the intervascular layer, or the fundamental layer of Tourneux, also called the tapetum; the layer of large vessels, and the lamina fusca (fig. 79).

The vitreous layer is very thin and transparent.

The chorio-capillaris is composed of a capillary network the meshes of which become closer as the retina becomes less vascular.

The fundamental layer of the tapetum only exists on a level with the tapetum lucidum—it differs in different species. Whilst in solipeds and ruminants it is formed of bundles of slightly undulating laminated fibres [*tapetum fibrosum*], in carnivora it is made up of superposed planes of cells called iridocytes, iridescent or shining cells (*tapetum cellulosum*) (Pouchet). It is absent from the eye of man, of the pig, and from monkeys [except the Lorides, Nycticebus and Galagos].

The tapetum has no vessels of its own, it is traversed only by the capillaries going from the layer of large vessels to the chorio-capillaris. The ocellated points of the tapetum lucidum are doubtless formed by the inosculations of these vessels.

The remarkable colouration of the fundus oculi of animals having a tapetum lucidum is produced by the decomposition of the light by different fibrous or cellular planes of the fundamental layer. [According to Lindsay Johnson, the colour of the fundus in those animals having a tapetum cellulosum is determined mainly by the colour of the retinal pigment; in those having a tapetum fibrosum by the structural colour of the tapetum modified by the colour of the retinal pigment; in those animals having no tapetum by the reflection from the choroidal pigment].

The layer of large vessels is made up of a very close network of large vessels—venous and arterial—surrounded by

elastic and muscular connective tissue fibres and of ramifying pigment cells.

The lamina fusca, formed of a layer of loose connective tissue with lymphatic lacunæ, unites the choroid to the sclerotic. It is especially in the meshes of this membrane that hæmorrhages and inflammatory exudates accumulate.

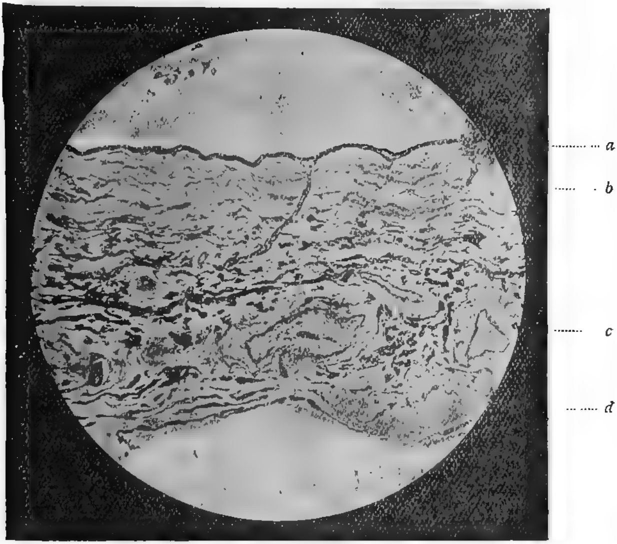


Fig. 79. Section of the choroid of a horse on a level with the tapetum lucidum. (*a*) Chorio-capillaris. (*b*) Fundamental layer of the tapetum with a capillary making the two vascular layers communicate. (*c*) Layer of large vessels. (*d*) Lamina fusca. (Nachet, ocul. 3, obj. 5).

Vessels of the uveal tract. The arterial circulation of the iris, ciliary body and choroid is assured by three kinds of vessels; branches of the external ophthalmic, formed from the internal maxillary; the posterior ciliary arteries, short and long, and the anterior ciliary.

The short posterior ciliary traverse the sclerotic in the posterior region near the papilla, and form in the choroid

the chorio-capillaris, and the layer of the large vessels. In albinotic eyes they can be seen with an ophthalmoscope forming beautiful stars, which can be studied more completely by transparence in enucleated eyes by illuminating the eye from behind, *i.e.* by interposing the eye between the source of light and the observer. In the horse and cat the short posterior ciliary arteries exchange numerous branches with the retinal vessels. (Leber).

The *long posterior ciliary* arteries two in number, an external and an internal, pass through the sclerotic with the preceding, going from before to behind, in the supra-choroidal space, and only giving off a few branches to the choroid. They end in the ciliary body and in the iris in which they form two arterial circles. The peripheral is known as the great arterial circle of the iris, the other peripupillary is known as the small arterial circle of the iris.

The *anterior ciliary arteries* coming from the arteries of the four recti muscles, traverse the sclerotic a little above the sclero-corneal limbus and terminate in the ciliary body and iris. The veins run into the anterior ciliary, and especially into the vasa vorticosa, which are united into four large trunks leaving the eye at the posterior hemisphere of the sclera.

For the Anatomy of the Iris consult H. Richter, Der muskulöse apparat der Iris des Schafes u. seine Beziehungen zur Gestalt der Pupille. Graefes Archiv für Ophthal. 1909, Bd. xx., Heft 3.

Id. Beitrag zur Anatomie der Iris des Pferdes, etc. Arch. f. vergleichende Ophthalmologie, II. Jahrgang, No. 7, s. 327-364).

T. Henderson. A note on the comparative Anatomy of the Ciliary Region. B.M.J., 1911, p. 1169.

Hess. A Comparative Study of Accommodation in the eyes of various animals. Zoologische Jahrbücher, Abt. für Anatomie, xxx., p. 339.

Ibid, Sitzungsberichte phys.-med. Gesellschaft, Würzburg, 1911, p. 52).

Physiology of the Uveal Tract.

Nutrition of the Eye. Essentially vascular, the uveal tract has control of the nutrition of the eye, particularly that of the non-vascular organs such as the lens, vitreous humour, and

the retina in animals in which the vessels of the retina are very short—as in equines. It has a great tendency to become inflamed, and in this case the organs which have the greatest need of its assistance are the first to suffer, and the lens, vitreous humour, and the retina are nearly always seen to be the seats of various lesions.

Secretion of the Aqueous Humour. The function of the ciliary body is to secrete the aqueous humour. Excreted in the vicinity of the pars ciliaris retinæ, this liquid passes into the posterior chamber, then through the pupil into the anterior. From there it is directed towards the spaces of Fontana, whence it is retaken into the canal of Schlemm and into the general circulation after being filtered through the sclero-corneal reticulum. The aqueous humour has still other ways of escape which are less important; the anterior face of the iris which absorbs it through its stomata; the supra-choroidal space which communicates with the exterior along the vessels traversing the sclerotic; the intervaginal and supra-vaginal spaces of the optic nerve.

When, from any cause, the secretion of the aqueous humour is lessened, the intraocular pressure falls because it is the result of an equilibrium between the secretion and excretion of the aqueous humour. This hypotony is one of the most constant symptoms of ciliary inflammation. If the excretory canals are obstructed the secretion continues, and an increased pressure results.

The aqueous humour is a limpid liquid normally containing a very small quantity of albumen. When drawn off from the anterior chamber the fluid very quickly reforms, but it then contains a larger proportion of albumen coming from the passive dilatation of the vessels allowing a greater quantity of plasma to filter through. The same effect is produced in the active hyperæmia of inflammations in which the excess of albumen in the aqueous humour is precipitated and participates in the formation of hypopyon.

The role of the iris in the visual act. The object of the iridial diaphragm is to prevent too great a number of

rays of light from entering the eye and blurring and impairing the functions of the retina, then to cut off the peripheral rays which, not being properly refracted, render the image indistinct (spherical aberration). The movements of the iris are active, produced by a constrictor muscle (the sphincter of the pupil), and a dilating muscle (membrane of Brücke); they may also be passive and are then caused by the flow of blood into and from the vessels of the iris; hyperæmia causes contraction of the pupil, and hypohæmia its dilatation.

The contraction of the pupil depends on the common oculo-motor (3rd nerve) which also innervates the ciliary muscle or the muscle of accommodation. Stimulation of the common oculo-motor contracts the pupil, section or paralysis of it causes dilatation.

Dilatation of the pupil depends on the great sympathetic. The pupillary reaction is not under the influence of the will: it is reflex or associated. It is *Reflex* when the stimulus passes from the centripetal nerves to the nerves of the iris by way of the nucleus of the common oculo-motor. The pupillary reflex is shown by a *contraction* under the influence of light; and by *dilatation* under the influence of sensory or psychic stimuli (fear). [The cat when purring alternately dilates and contracts its pupil to a slight extent, apparently in co-ordination with the sounds emitted. Birds seem to contract and dilate the pupil at will].

The pupillary reaction is *Associated* when the pupillary fibres of the common oculo-motor act simultaneously with the other fibres of the nerve; the fibres of the internal rectus and of the ciliary muscle. There is a contraction of the pupil in convergence (synergy with the internal rectus), and in accommodation (synergy with the ciliary muscle). Under normal conditions the pupil is always a little more dilated in young than in old animals. Moreover, the dilatation should always be the same in both eyes. Inequality in the size of the pupils is always a pathological sign (*anisocoria*).

Inflammation of the Uveal Tract.

Inflammation of the uveal tract, generically termed uveitis, may be generalised to the whole uveal region, when it is known as irido-cyclochoroiditis or more simply as irido-choroiditis; or localised to one of these divisions, in this case being called iritis, cyclitis or choroiditis. But on account of the distribution of the vessels a fairly marked pathological independence exists between the anterior segment of the uvea—the iris and ciliary body, and the posterior segment—the choroid, so that irido-cyclitis and choroiditis will be dealt with separately. Besides, as the vascular and uveal membrane is that in which inflammation most easily extends, and as it may occur in all degrees, uveitis is often polymorphous. In spite of this nothing is easier than to recognise them when it is known that they are manifested by an exudate localised to one or other region of the eye, according to whether the inflammation originates in the iris, ciliary body. or choroid.

It seems best therefore to give first a general outline of the semiology, pathological physiology, and anatomy of uveitis. This is one of the most interesting parts of the pathology of the eye, in fact, the semiology is closely connected with the study of the lesion. The inflammation will therefore be followed through the different segments of the uvea with the modifications which it undergoes in each of them. This should prepare for the diagnosis of the multiple cases which are met with clinically and which cannot be completely classified.

Symptoms, Pathological Anatomy, and Physiology of Uveitis.

The Horse. Under the influence of some irritant, the iris and ciliary body, two essentially vascular structures, become the seat of a more or less intense *hyperæmia*. This hyperæmia is manifested by external and internal phenomena. Externally it is shown by the distension of the ciliary vessels which penetrate the sclerotic all round the cornea. This region, pink in its normal condition, then becomes overrun with large purplish

coloured vessels situated under the conjunctiva and remaining fixed when this membrane is made to glide over the eyeball. This is the *ciliary* or subconjunctival injection.

The transuded plasma does not cause the sclerotic to swell, this membrane being too resistant, but penetrates the cornea in which it produces a cloudiness which may be localised or generalised; it penetrates the conjunctiva which is itself congested, for it receives vessels from the ciliary, always becomes a little infiltrated and sometimes, but not commonly, so much so that the infiltrate collects round the cornea and forms a swollen ring—the condition being known as *chemosis.* Later, when hyperæmia persists, the loops which the ciliary vessels normally form near the anterior border of the sclerotic give rise to other very fine vessels, which penetrate the cornea at its periphery and advance singly, radiating towards the centre of the cornea, and produce a greyish cloudiness. These vessels, situated in the parenchyma of the cornea, have been studied under the head of parenchymatous keratitis.

This hyperæmia, by causing pressure on the nerves has the further effect of determining *reflex symptoms*, which attract the attention of the attendant, and to which undue importance is given in veterinary literature. These are lacrimation, photophobia, pain, and swelling of the eyelids.

Lacrimation is more or less abundant, the tears being quite clear and due to a hypersecretion of the lacrimal glands. The irritant action of this liquid is due to its chemical composition and mechanical action, and not to any special irritant properties which were formerly attributed to it. The tears are mingled with mucus, or even muco-purulent secretion arising from the conjunctival catarrh.

Photophobia or increased sensitiveness to light is shown by closure of the eyelids to a variable degree, and by the orbicular muscle of the eyelids being in a state of spasm. This spasm opposes considerable resistance to attempts at opening the eyelids for examination. The occlusion of the lids may also result from their being tumefied or œdematous from the relations existing between the palpebral vessels and the anterior ciliary.

The *pain*, which is constant and sometimes intense, as is known from comparative ophthalmology, is shown by the attitude of the animal, the head being held low, resistance being offered to attempts at examination; there is sometimes loss of appetite and a rise of temperature.

The ciliary body not being visible and the choroidal vessels being masked by the tapetum or by the thick layer of the retinal pigment, internal hyperæmia only shows perceptible modifications in the iris. Turgescence of the vessels modifies its colour and especially its glistening appearance; the anterior face assumes a dull grey tint. It constricts the pupil and, to some extent, paralyses the iris, keeping the pupil in a state of miosis. Mydriatics no longer act, or in any case only act incompletely.

The congestion of the iris and ciliary body is still better shown when it gives rise to hæmorrhages, which most often appear in the form of little filamentous clots, coming from the irido-corneal angle or from the posterior chamber and floating in the aqueous humour without lessening its transparence.

It is very rarely that the effusion is sufficient to constitute in the inferior part of the chamber a true *hypohæmia*. This phase of hyperæmia may constitute all the disturbance; this frequently happens when the iris is secondarily affected from one of the surrounding parts, particularly the cornea.

When the affection runs its full course the stage of hyperæmia is followed by that of *exudation*, which can be observed in the iris, ciliary body and choroid.

In the Iris. The fibrin of the blood plasma, as well as the leucocytes are shed into the meshes of the tissue of the iris, on its surface and into the aqueous humour. The exudate swells the fibrillary interstices, and tends to contract the pupil and to render the iris rigid and insensitive to mydriatics. The covering epithelium splits and falls off, leaving bare dull spaces. The iris assumes a yellowish or yellow brown tint, often more marked below the pupil.

The exudation may confine itself to this interstitial *parenchymatous* infiltration without affecting the aqueous humour, as has been seen by Nicolas in several cases in the horse.

When the exudate spreads over the surface of the iris it soon produces a turbidity of the aqueous humour, looking as if it were caused by particles of dust or flocculi, which are deposited on the walls and in the lower part of the anterior chamber. The material which collects here, whatever be its nature, closely resembles pus in colour and consistence; the condition is called *hypopyon;* it often contains blood clots, or streaks of blood, but it is rare to find the blood and pus intimately mixed. In other cases the exudate forms small, whitish, floating filaments, which cause no inconvenience and have no tendency to collect or form hypopyon.

The exudates deposited on the walls render the cornea opaque, and form a more or less thick skin on the anterior face of the iris, which assumes the colour of a decaying leaf [*sere* leaf of the old farriers or hippiatrists]. They also accumulate in the pupillary opening, where they may form a more or less opaque membrane *(pupillary membrane).*

In the posterior chamber their presence is not directly revealed unless they form a projection into the pupil, as if passing from one chamber to the other.

They thus glide over the lens, and become attached to the anterior capsule, on which they may form a more or less opaque deposit. In any case they have a tendency, which they owe to their anatomical constitution, to establish adhesions between the different parts of the anterior segment of the eye, especially between contiguous surfaces. The margin of the pupil, being supported on the anterior face of the lens, catches the exudates on its edge, and is particularly exposed to the risk of contracting adhesions, which will be dealt with under the head of *posterior synechiæ.* But they may also establish abnormal adhesions between the anterior face of the iris and the posterior face of the cornea; in this case they are known as *anterior synechiæ.*

In the ciliary body. The exudates of the *ciliary body* which, other things being equal, are abundant, on account of the size of this region of the uvea and its richness in blood vessels,

may come through its anterior face and fall into the anterior chamber, after having traversed the spaces of Fontana, or pass through its inferior face, and thus into the posterior chamber, or lastly, through its posterior face, whence they may spread out into the anterior part of the vitreous humour immediately behind the lens.

Those which fall into the aqueous humour help to increase the turbidity of this liquid, to thicken the deposits on the walls, and to increase the hypopyon, but there is no means of identifying them. It is otherwise with exudates arising on the posterior face of the ciliary body. As soon as they appear in the anterior parts of the vitreous humour, or on the posterior face of the lens, it is safe to conclude that the ciliary body is attacked. The vitreous humour is then the seat of a fine, dust-like turbidity which is capable of being resorbed somewhat quickly, and which gives the deep membranes a blurred appearance and a yellowish colour; or it may be penetrated by membranes and filaments which leave it relatively transparent, but which are much more slow in disappearing, and rarely do so completely.

In the choroid. The exudates are less abundant and less penetrating than those of the ciliary body. They raise up the retina, detach it from the choroid, penetrate it, and in so doing lessen its transparence, and may spread into the immediately surrounding parts of the vitreous humour. But probably on account of their filtration they never cause more than a slight haziness, which renders the vessels of the retina, the region of the papilla, and the ocellated spots of the tapetum more difficult to see. All the regions of the fundus oculi, so clearly defined in a normal eye, tend to become uniformly discoloured, and of a dull or dirty yellow tint.

Symptoms of inflammation of the iris and ciliary body are always accompanied by a modification of the ocular tension, which must be carefully estimated, as it plays a great part in the prognosis. *It is exceptional for the ocular tension to increase, and when it does so it is always at the commencement of*

the affection; on the contrary, it is the rule for it to diminish even in the mildest cases.

When the activity of the inflammation is exhausted the body commences to repair the damage; this is the beginning of *recovery which in this affection is rarely synonymous with integral resolution.* It is produced by the resorption of the effusions or by organisation of false membranes.

Resorption may be complete, but this is only when it commences at the beginning of the disease, or when it is in a mild form. In twenty-four hours a hypopyon may be produced, which is sometimes resorbed twenty-four to forty-eight hours after.

In most cases the eye is less prompt in recovering itself, and it is very rare that there are not some traces left which, a long time after, can be cited as evidence of a previous attack of uveitis. These remains are the result of the *organisation* of precipitated fibrin or false membranes. They are composed of a tissue comparable to that of cicatrices, in the midst of which there frequently exists some granules of pigment—proving their origin. According to their situation these remains give different appearances in the eye which it is necessary to be able to recognise.

Opacities of the Cornea. The modifications of the cornea have been studied under the affections of this membrane (see *Superficial*, *Parenchymatous*, and *Deep Punctated Keratitis*).

Anterior Synechiæ. Adhesion of the anterior face of the iris to the posterior surface of the cornea sometimes results from the organisation of hypopyon and constitutes an *inferior symphysis.* It is rarely seen at any other point unless resulting from atrophy of the eye, and at the time when the anterior chamber disappears.

Posterior Synechiæ. Any adhesion between the posterior face of the iris and the lens is thus designated. They are most frequent opposite the pupillary margin. The pupil being contracted at the time of the adhesion the synechia

appears in the form of a spur when the iris retracts and the pupil remains irregular. The margin of the pupil, which is slightly thickened in a normal condition, becomes thinner at the adhesion from the tension on it when the iris dilates. The tissue uniting the two structures is partly formed of a greyish white portion, which is the true cicatrix, and of a pigmented part coming from the uveal layer of the iris.

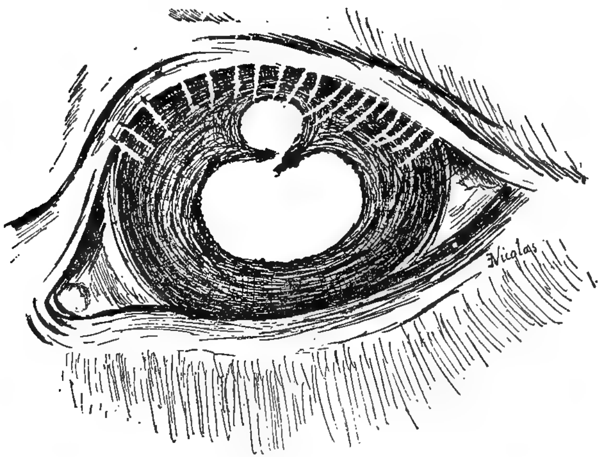


Fig. 80. Posterior synechiæ shown by the action of atropine. (Eye of horse).

Being generally most easily seen when the pupil is normally dilated, synechiæ are always shown up by the instillation of atropine. (Fig. 80). Under the influence of the retraction of the iris or of the action of mydriatics the synechiæ may break down; in this case they leave on the surface of the anterior lens-capsule pigmented spots which persist for a long time; very often they are permanent. (Fig. 81).

Adhesions existing at any point on the posterior face of the iris are not as a rule visible until the pupil has been artificially dilated. But in some cases synechiæ may enclose a space which by becoming filled with fluid has the appear-

ance of a cyst. The iris is then pushed forward and forms a localised ectasia, the diagnosis of which is easy.

Occlusion of the Pupil. (Fig. 82). This results from the conversion of the iris into a continuous membrane, either by direct union of the pupillary margins or by the intermediary of a false pupillary membrane. The two chambers of the eye are thus completely separated. The first form, generally associated with seclusion of the pupil, is commonly encountered in atrophy; the second is more rarely observed.

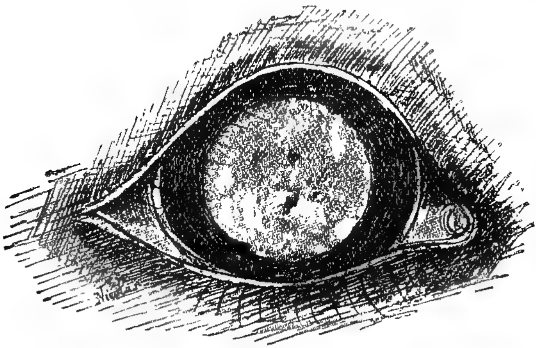


Fig. 81. Traces of the uvea on the anterior capsule of the lens, resulting from the breaking down of posterior synechiæ by atropine (eye of horse).

Seclusion of the Pupil. (Fig. 83). This term is applied to the condition in which the margin of the iris is adherent to the anterior capsule of the lens throughout its whole extent. The aqueous humour cannot pass from one chamber to the other, but by accumulating in the posterior chamber it pushes the iris forward, so that the pupil comes to be situated in a funnel-shaped depression; this condition is known as annular posterior synechia (Fr. *iris en tomate*).

In cases of pupillary seclusion the margin of the iris soon becomes thin and ruptures, and the whole membrane atrophies in consequence of its not being able to move.

Opacities of the Lens. These will be considered under diseases of the lens.

The part played by exudates which have invaded the vitreous humour, and which have come from the ciliary body or choroid has still to be considered.

Whilst the exudates are confined to the surface of the ciliary processes they are only objectively shown by the diminution of ocular tension which they cause, without doubt by compression and atrophy of the ciliary body—the supposed source of the aqueous humour.

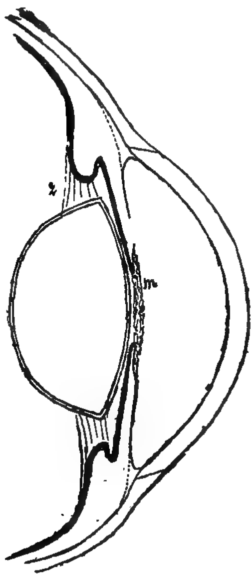


Fig. 82.—Occlusion of the pupil by a fibrinous exudate *m*.

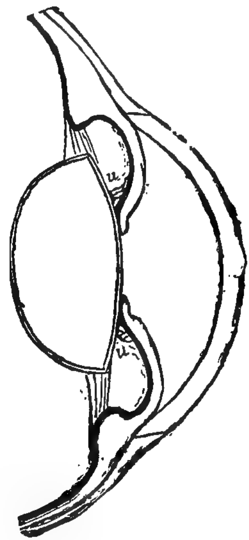


Fig. 83.—Seclusion of the pupil (iris en tomate.)

But if they force their way outwards they first of all encounter the tract of the zonula of Zinn, the suspensory ligament of the lens which they (more or less) destroy, thus preparing for sub-luxation or luxation of the lens. Then continuing their course to the surface of the posterior capsule of the lens, if abundant, they there form an opaque cover

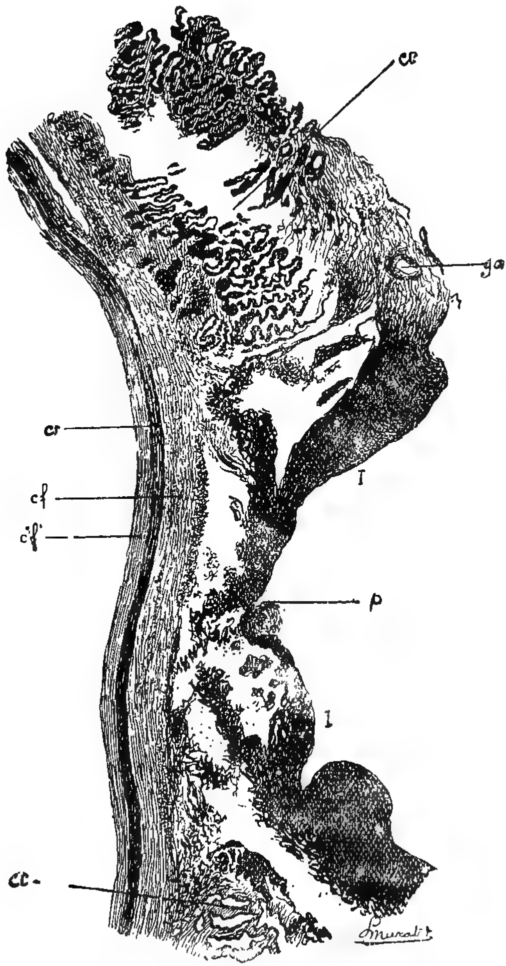


Fig. 84. Occlusion and seclusion of the pupil (Horse). (Mag. x 18).

cc, *cc*, ciliary bodies. *cf*, *c'f'*, fibrous shells covering the two faces of the anterior of the lens capsule. *cr*, *pa*, great arterial circle of the iris. *I*, *I*, iris adherent to the anterior lens capsule; the pupillary margins are united to the pupil *p*, which is virtual. (The sclerotic and cornea have been removed to facilitate the cutting of the section).

which, by its increase, has all the characters of an elastic band; this causes atrophy and destruction of the eyeball. At first following the curvature of the lens this band straightens, shortens with the progress of its organisation, pushes the lens and iris forward, atrophies them and by compressing them against the cornea tends to unite the opposite walls of of the eyeball. (Fig. 85). At this stage of destruction the

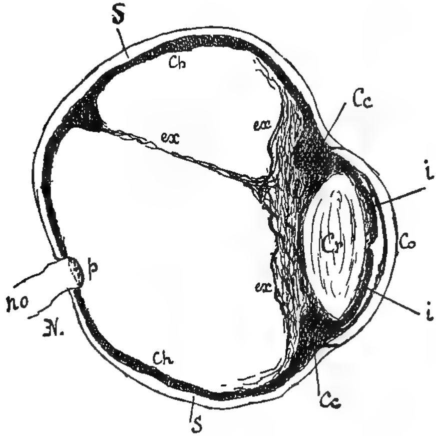


Fig. 85.—Eye of a horse undergoing atrophy.

The sclero-corneal furrow is more marked than normally. The lens (*Cr.*) and the iris (*i*, *i*,) are pushed back against the cornea by a post-lenticular band of exudate (*ex. ex.*) The papilla (*p*) is granular and projects into the vitreous humour. The choroid (*ch*, *ch*,) is very thick. The retina has disappeared by resorption.

uveitis ceases to be of clinical interest, but a few words will be devoted to the lesions under the head of pathological anatomy.

In the vitreous humour the products of inflammation by becoming organised disintegrate, soften and liquefy this medium, and either directly or indirectly cause detachment of the retina or even rupture of the choroid. The effusions from the choroid form on its surface bands or patches of

cicatricial appearance which bring about atrophy of this membrane as well as the retina.

Atrophy of the eye is manifested by an accentuation of the furrow at the junction of the cornea and sclera; by the eyeball being less prominent between the eyelids—a condition easy to recognise, even at its commencement [or before atrophy becomes evident], by the examiner so placing himself that he can look at both eyes from the front at the same angle, by wrinkling of the upper eyelid—a point which used to be considered very important in regulations dealing with horses as it was thought to be characteristic of "periodic ophthalmia."

However, it is easy to understand, as has been explained elsewhere, that this wrinkling is only a secondary symptom having no relation to the etiology of the inflammation, but depending solely on the stage of atrophy of the eye. The upper eyelid, obliged by atmospheric pressure to follow the eyeball as it retreats, falls in on a level with its free border, and at the same time it sinks and presents between the ciliary border and the orbital arch, grooves or folds more than usually marked.

The cornea shrinks in every dimension, and the membrane of Descemet, not being able to follow this movement on account of its glassy structure, puckers, breaks, and forms on the posterior face of the cornea, already more or less cloudy, whitish tracks which may be confounded with cicatricial exudates.

Pathological anatomy. To complete this account of the symptoms, in which all the lesions so far mentioned can be recognised on the living animal by one or other of the methods of examining the eye, a brief account of the macroscopic and microscopic appearances which can be studied post mortem may be of interest. (Sichel, Hocquart and Bernard, Dexler, Bayer, and Nicolas). The cornea and lens are often sufficiently clear to allow of an oblique or an ophthalmoscopic examination post mortem. A good idea of the limpidity of the aqueous humour or of the vitreous

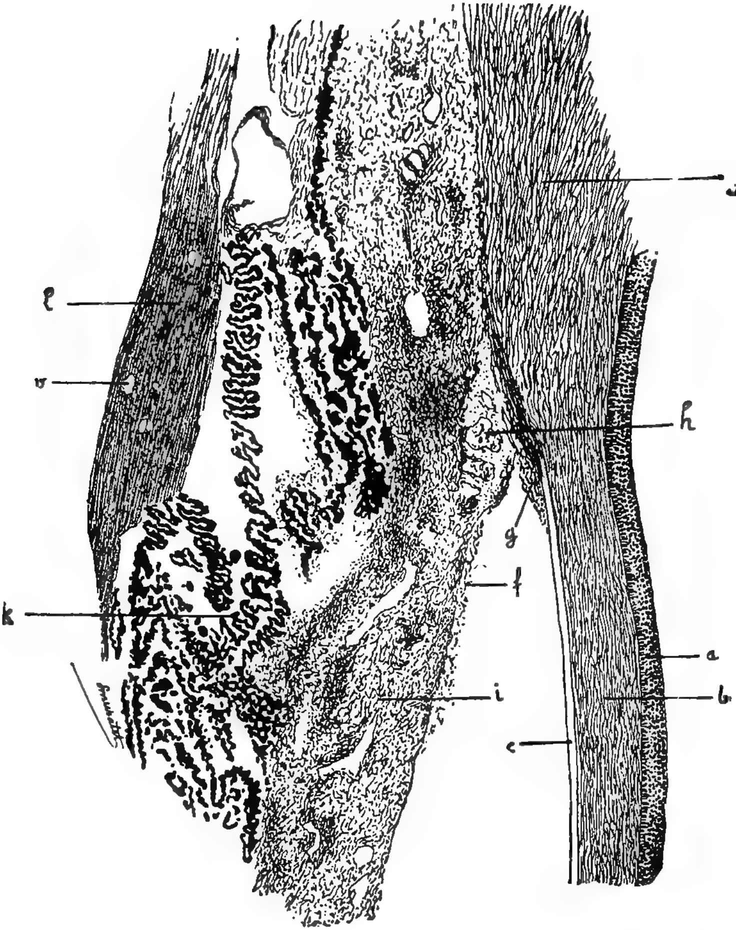


Fig. 86. Mesial section on a level with the angle between the iris and the cornea, of the eye of a horse attacked with irido-cyclitis, not having undergone atrophy.

A fibrous exudate (*l*), vascularised (*v*), covers the ciliary body (*k*). The spaces of Fontana (*h*) are obstructed and partly destroyed be an exudate (*g*), which can be seen (*f*) on the anterior face of the iris (*i*).

can thus be obtained, or of the presence of floating exudates which might escape at the moment of cutting into the eye.

For the oblique examination there is no need of a lens, the eye being held between the finger and thumb in such a manner that rays of light coming from a window penetrate the anterior chamber. Thus the slightest opacities of the deep face of the cornea are seen better than in a section of the eye. The information furnished by this previous preliminary examination of the eye being noted, the eye should be opened. To do this two incisions should be made, which will allow the whole eye to be examined without disturbing the parts too much.

First a mesial section, if the cornea is opaque and does not allow of an examination of the alterations in the anterior chamber; (2) in the contrary case, an incision at right angles to the preceding one and passing about 1.5 cms. behind the sclero-corneal limbus in order not to damage the ciliary body.

As a general rule the alterations met with deep in the tissues are infiltrations of small rounded cells, usually forming nests; atrophic alterations or disorganisation. On the surface of the tissues and in the liquid media are fibrinous exudates, if they are recent, or fibro-cellular or vascular if of old standing.

The eyeball. This is more or less atrophied and deformed. Atrophy may reduce it to the size of a small nut.

The cornea, sometimes reduced to 1 cm. or 2 cm. diameter, may have its curvature increased or diminished. It may be transparent or opaque; in the latter case the opacity is due to parenchymatous exudates, to folds and fissures in the membrane of Descemet, and sometimes also to plastic deposits covering the membrane on both faces (*See* fig. 64).

In the *anterior chamber* the hypopyon is formed of fibrin, a few cellular elements, pigment, and sometimes of blood.

Although cellular exudates are met with in the parenchyma of the iris, alterations of this membrane are rather passive, and result from the action of the exudates which are found on its surface, compressing it in one place and stretching it

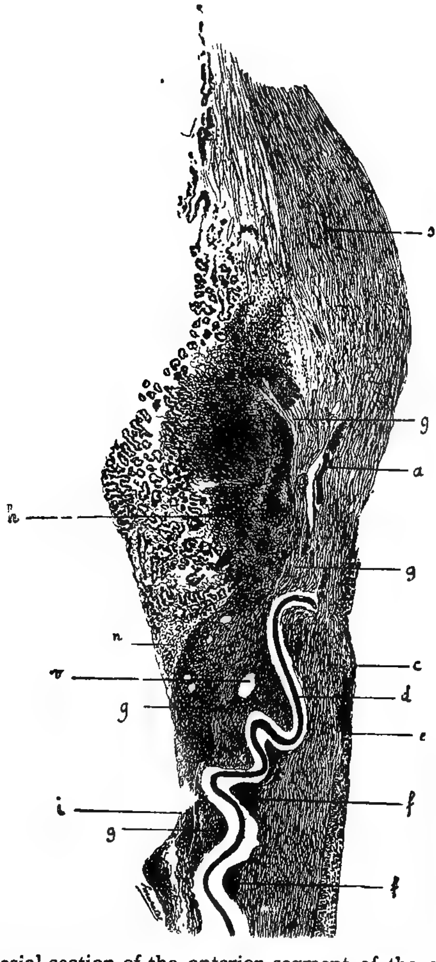


Fig. 87. Mesial section of the anterior segment of the eye of a horse suffering from irido-cyclitis, in a stage of atrophy. (Mag. x 14).

a, The superior part of the membrane of Descemet, marking the irido-corneal angle completely obstructed by organised exudates *g g*. The membrane of Descemet (*d*) is detached and separated from the cornea (*c*) and from the iris (*i*). The two last-named membranes are covered with fibrous exudates (*f f*) and (*g g*). The anterior chamber has almost completely disappeared. The ciliary body (*h*) is reduced to a mass of pigment.

in another; at other times, by pressure of the lens upon it, it becomes atrophied, and thinned until it is reduced to a fenestrated membrane in which a few exposed vessels still run. In some sections nothing else may be able to be distinguished but masses of pigment cells, rounded or more or less irregular, resulting from the aggregation of atrophied cells, these masses being separated by some fibres representing the last vestiges of the iridal structure. In the ciliary body there are the same cellular infiltrations of the parenchyma; the same exudates on its surface and in the spaces of Fontana; and the same atrophic alterations of its stroma, which is reduced to a mass of pigment. The lens is rarely free from injury. The capsules show small opacities on their external faces, which are much more easily seen with an ophthalmoscope than the naked eye. Sometimes both faces are covered with a croupous membrane, which has been found up to 2 mm. in thickness, infiltrated with calcareous matter or transformed into osseous tissue (Fig 84).

The nucleus of the lens enclosed in this shell is more or less atrophied, reduced to an opaque yellowish chalky body, sometimes to a mass undergoing softening, or it may even be completely liquefied. It often happens in a section that the parts constituting the fibrous shell are not intimately united, and separate like the layers of an onion which is becoming dry; in such a case it might be thought that a division of the capsule of the lens was taking place, and to this must be referred the fact of double anterior capsules being met with by Sichel in the eyes of horses attacked with periodic ophthalmia.

In other cases the lens is torn from its ligament and then, as a rule, it falls back into the vitreous humour.

When the vitreous humour is altered its lesions are all passive. It is penetrated by small fibrinous filaments or membranes which sometimes cross it from one point to another uniting the ciliary body to the choroid. It atrophies and shrivels, forming a gelatinous-looking mass, decreasing in size, but always remaining adherent to the ciliary body and

to the posterior face of the lens, so that it leaves between its deep face and the cavity of the eye a space which is filled with liquid. This is clear, citron-yellow in colour, occasionally greasy looking, or in some eyes it is a syrupy chocolate-coloured liquid. In other cases the whole space is a clot of blood, or filled up by fibrous, or even bony tissue. Histologically, when a section is made through the vitreous humour, reduced to a small size, it seems to be largely formed of a kind of membrane folded an infinite number of times on itself. Crystals of cholestrin are also found in it.

The retina is only found in position in cases in which the vitreous is not at all or only very slightly atrophied.

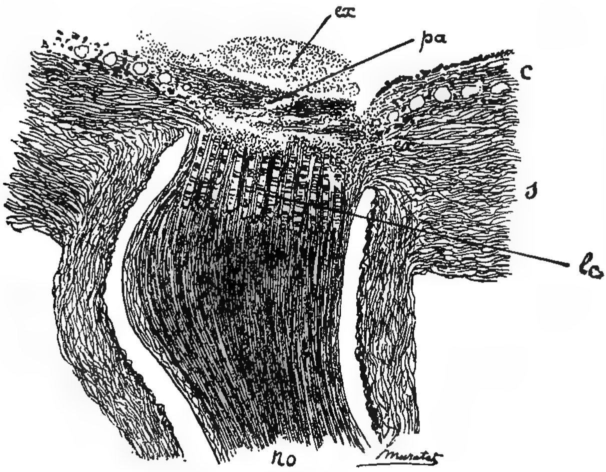


Fig. 88. Section through the papilla of a horse suffering from irido-choroiditis. (Mag. x 7).

The papilla (*pa*) is granular (*ex*) and projects into the vitreous. *lc*, the lamina cribrosa—very diagrammatic.

As a general rule it follows the forward movement of the vitreous humour, always remaining attached to it in such a way that it ends by forming a funnel, the smaller end being at the papilla and the larger at the ora serrata. It is thinned,

split up, atrophied and torn. Sometimes even no trace of it may be found. Under the microscope it is reduced to a hyperplastic connective tissue stroma in which only the internal and external molecular layers, intermingled and atrophied, can be recognised. The nerve fibres, the ganglion cells, and the rods and cones have disappeared.

The papilla is often the seat of a granulation which may project 1–2 mm. into the interior of the eye. This granulation which may be the result of proliferation of the cellular elements of the neuroglia, seems also to be a tissue formed of a deposit conveyed to the papilla by the retinal funnel. (Fig. 88).

The choroid shows on its surface small masses of easily disintegrated exudate, giving it a downy appearance, partly due

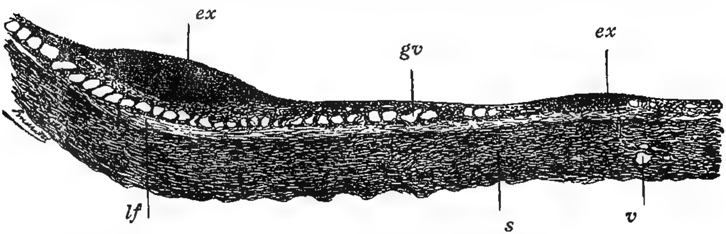


Fig. 89.—Section through the wall of an eye attacked with irido-choroiditis. (Horse). (Mag. x 7).

(*ex ex*) Exudates on the surface of the choroid, compressing and leading to atrophy of the membrane. (*gv*) Layer of large vessels. (*lf*) Lamina fusca. (*s*) Sclerotic. (*v*) Perforating vessel.

to the rods and cones of the retina remaining adherent to it. Sometimes there is a plastic deposit compressing the membrane and causing it to undergo atrophy. (Fig. 89). Its thickness, doubled or even trebled in atrophied eyes, is the result of the tissue gaining in thickness what it loses in surface, but it is sometimes due to congestion of the vessels, or to a serous or hæmorrhagic infiltration of the supra-choroidal spaces. In microscopic sections cellular infiltrates can be seen in the vascular layer. These vessels are gaping, filled

with globules; their endothelium is exfoliated, and covered with clots in process of organisation. In other cases the vascular walls are broken, giving rise to hæmorrhages which spread everywhere through the meshes of the loose tissue of the lamina fusca, or find their way into the vitreous humour.

The pigment, irregularly distributed, forms masses in which the pigment cells can no longer be distinguished.

The sclerotic undergoes hardly any alteration, except that it is thickened considerably when the internal structures atrophy and disappear by absorption. It can only follow the course of the retraction of the contents of the eye, and it therefore folds on itself through the undulation of its fibres.

Anterior Uveitis or Irido-cyclitis. *Clinical forms in the horse.* These are especially dependent on the intensity of the inflammation, the etiology giving them no appreciable characteristics.

Acute Irido-cyclitis. This is an invading form, and gives the most complete picture of uveitis, from the intensity of symptoms and their appearance in the three segments of the uvea, the iris, ciliary body and choroid. It is also the most serious form from the point of view of its effect on the sight, on account of the lesions which it may cause in all parts of the eye.

Its initial stage is sudden, with much disturbance, accompanied by prostration of the animal, loss of appetite, or even rise of temperature. The eyelids are swollen to such an extent that a traumatism may be suspected, the eye is closed, discharges tears, and is painful. The ciliary and conjunctival injection is intense, and may or may not be accompanied by chemosis. The cornea is affected, opalescent, and white or yellow at a point which will suggest the formation of an abscess. In an early stage it is invaded by a circumcorneal vascularity which may advance almost as far as the centre, and in a single night a deposit having all the appearances of pus, sometimes mixed with blood, is formed in the bottom of the anterior chamber.

The iris is dull, grey and yellowish ("dead leaf"). The eye

is soft. On ophthalmoscopic examination the pupillary field is illuminated uniformly, and is of a greenish colour (teinte glauque des hippiâtres), and in it can sometimes be recognised, as if through a thick fog, a slightly reddish surface surrounded by whitish rays: this is the papilla, surrounded by

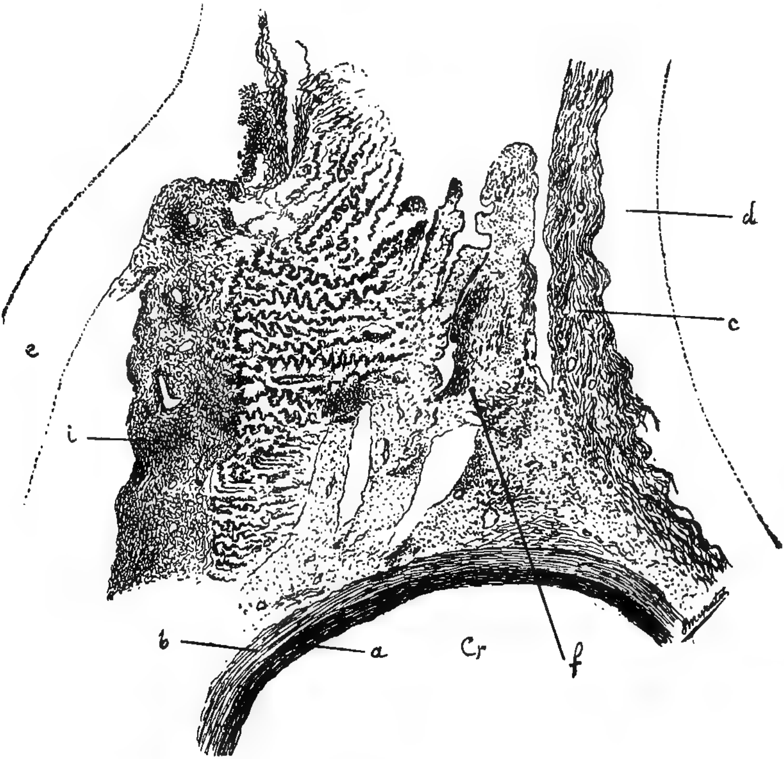


Fig. 90. Section through the eye of a horse having undergone atrophy.

A fibrinous exudate (*f*) unites the posterior wall (represented by the choroid (*c*) and the sclerotic (*d*)) to the anterior segment of the eye (represented by the iris (*i*) and the cornea (*e*), and to the lens (*cr*), the anterior capsule (*a*) of which is covered by a fibrous false membrane (*b*).

small areas from which the retina has been detached, proving that the choroid has participated in the inflammation.

After very variable lengths of time the inflammatory phenomena subside, the exudates begin to be resorbed, and the eye becomes more and more easy to illuminate, if, as in some cases, a complete cataract has not at the first onset destroyed the transparence of the lens.

Then, the large masses of exudate in the vitreous humour, being more slowly resorbed, become quite visible; for the same reasons the presence of exudates in the choroid can be more easily determined from the blurring of the tapetum, the vessels of the retina, and the borders of the papilla. The resorption of the effusions, which are always abundant, is long in being completed, and it is only after three weeks, a month, or more, that the media regain a relative transparence. But it must be mentioned that the eye never returns to its normal state of tension, and does not regain either its proper prominence between the lids or the healthy brilliancy of a sound cornea.

Subacute Irido-cyclitis. The symptoms are less acute. The eye is less closed, and only a little moist. The cornea sometimes remains transparent, but it often presents an opalescent infiltration, limited to one or several segments adjoining the periphery. These form depressions, while the intermediate transparent parts seem to form facets. The circumcorneal circle of vessels is often absent.

The aqueous humour contains whitish filaments in suspension, which only slightly, if at all, interfere with its transparence; and these appear and disappear sometimes with very great rapidity. They may be met with attached at one end with the other end free on the margin of the pupil; they rarely form hypopyon. They sometimes support streaks or small clots of blood. The brilliancy of the anterior face of the iris is often normal. The pupil is regular, always slightly contracted, and to a certain extent is resistant to the action of instillations of atropine; that is to say, it is necessary to make repeated instillations on several days to obtain an

appreciable dilatation which is, as a rule, progressively produced.

The vitreous humour is the seat, principally in its anterior parts, of turbidity very like that of the aqueous humour. The papilla is often a little congested. Tension is always negative, and the eye may be as soft as in the acute form.

After three or four days, especially if atropine be instilled, the eye loses its moist appearance, the eyelid is raised, and often after eight days the corneal infiltration, and the exudates in the aqueous and vitreous humours are absorbed. The re-establishment of movements of the iris is much more slow; for a long while the pupil is regularly dilated by atropine, but only incompletely.

Subacute irido-cyclitis is rarely followed by *restitutio ad integrum*; hypotension, filaments in the vitreous humour, corneal and lenticular precipitates, all persist for some time and allow a retrospective diagnosis to be made.

Chronic, insidious, or abortive (*frustes*) **Irido-cyclitis.** The following forms of uveitis only distantly resemble the previously described varieties, in which the exudates in the aqueous humour particularly attract attention. Here the chief symptoms which allow of diagnosis have to be sought for in the state of injection of the ciliary body, hypotension, and the resistance of the pupil to dilatation with atropine.

These forms of uveitis are all the more interesting because they may be mistaken for slight affections such as conjunctivitis, or superficial keratitis; their immediate effects are almost negligible from a functional point of view, although they often acquire considerable gravity. As will be seen, as a general rule, uveitis is commonly followed by relapses or secondary attacks, thus gradually leading to loss of sight, if this has not resulted from the first onset.

Corneal forms. A horse may be examined in which, in place of the common signs of photophobia, lacrimation, etc., there are one or more white spots of infiltration of the cornea *with a broad base turned towards the sclerotic, the borders well-marked, and standing out from the other parts of the cornea*, which

seem to form facets and are perfectly bright and transparent. There is not the least exudate in the aqueous humour, but the pupil is contracted and insensitive to atropine. This will be a case of hyperæmia of the iris, for in a few days it will be found that, under the influence of repeated instillations of mydriatics, the eye will become a little softened, the corneal symptoms will disappear, but the resistance of the iris to the action of mydriatics will still remain. A relapse, which will very likely occur, will distinguish it from keratitis.

Deep punctated keratitis. This lesion, described already under Keratitis, is the only symptom of an inflammation which attacks the uvea without, as a rule, attracting any attention.

Iridal Forms. *Dry iritis.* This form is characterised by the development of synechiæ without any reactionary signs; it has been met with in the horse by Grandclément, Cadéac, and Rolland, and is described in man under the name of "quiet iritis." In these cases an eye which has never shewn any apparent inflammatory phenomena, and the transparence of which is perfect, is found to have one or more synechiæ.

Parenchymatous iritis. The exudate is confined in the parenchyma of the iris without causing the least disturbance of the aqueous humour. The iris, especially in its lower half, shows a yellowish colouration, which should not be confounded with an abnormal colouring of the iris (heterophthalmos) if the ciliary injection be noted at the same time, as well as the constriction of the pupil, and its resistance to mydriatics. In a case which was accompanied by commencing atrophy of the eyeball without loss of transparency of the media, Nicolas observed a symptomatic hypermetropia of 2.5 D.

Ciliary forms. *Spurious cataracts.* The ciliary exudates are deposited on the anterior and posterior lens capsules, the pupil being miotic and not completely dilated with atropine.

The eye may be normal externally. One case was observed by Nicolas of a horse which for a year was attacked with an unilateral irido-choroiditis and with four recurrences. After this, the other eye, so far healthy, showed capsular opacities in

the pupillary field, the thickness and consequently the opacity of which went on increasing, first in the posterior lens capsule, then in the anterior, till in three weeks it formed an almost complete spurious cataract. In proportion as the opacity became denser on the faces of the lens, so the pupil contracted and became more resistant to the action of atropine.

During the whole time these opacities were forming, the anterior media remained absolutely transparent.

Relapse and recurrence in inflammations of the Uvea. When the uveal tract has once been the seat of an inflammation, it is particularly liable to a second and further attacks. These attacks, according to the manner in which they are produced, give the uveitis a peculiar character of its own. Thus it is that an eye suffering from irido-cyclitis, which is in the stage of resorption or organisation, may be the subject of a fresh acute attack with the formation of a second hypopyon, etc. In such a case it would seem that the cause cannot exhaust its activity at the first onset, and becomes passive to again assume an active phase when the body has repaired the damage done by the first attack. Such attacks are said to be *subintrant* or that there has been a *relapse* of the affection. It is in reality the same affection, the course of which is marked by periods of repose, increase and decline. The attacks forming these relapses always follow fairly closely on one another. In other cases the attacks are separated by intervals of three months, a year, eighteen months, with no continuity between them, and these are called *recurrences*.

Relapse and recurrence are not merely terms to characterise the course of the inflammation; they also give a more complete idea of their gravity. Relapses of uveitis are always more serious than recurrences, because in the first case lesions are added to lesions without the system having time to repair the damage done.

The attacks have this peculiarity, that they need not necessarily resemble one another. An acute attack may succeed an abortive, and *vice versâ*.

It can be shown that relapse and recurrence are not characteristic of the same cause. Though both relapse and recurrence have for a long time been attributed, in man, to an irritant action determined in the eye by the tension of synechiæ, this explanation has now to be abandoned in view of the fact that they have been shown to occur without the presence of synechiæ. In the horse abortive attacks without synechiæ are quite as subject to relapses and recurrences as the forms with synechiæ.

Dr. Dor having discovered in a case of irido-cyclitis in a horse a diplococcus which experimentally reproduced the disease with paroxysms, has explained the above facts by referring them to a biological character of the infective agent. Dor's diplococcus lives better in an acid medium than in an alkaline. Now the vitreous humour of the horse should be acid. When carried into the vitreous humour the organism grows and causes inflammation of the uvea, the exudates resulting from which are alkaline, the vitreous humour loses its acidity, and the growth of the organism is arrested. The uveal inflammation then enters into a chronic phase until the vitreous humour regains its normal acidity, when the cycle re-commences.

This theory explains nothing but the relapses; it cannot be applied to the recurrences which are seen a long time after the vitreous humour has regained its normal reaction. In this case the theory of *locus minoris resistantiæ* must be allowed.

Etiology of Irido-Cyclitis.

In the horse irido-cyclitis may be classified according to its etiology as follows:—

Irido-cyclitis from General causes	...	Primary. Symptomatic.
Irido-cyclitis from Local causes	...	Extension from neighbouring lesions. Traumatic. Sympathetic.

Primary Irido-cyclitis. [*Synonyms.*—Irido-choroiditis recurrens; Irido-choroiditis; Periodic, recurrent, remittent, rheumatic, specific or constitutional ophthalmia; Moonblindness;

Lunatic Eyes. *Fr.* Maladie lunatique; Fluxion périodique. *Ger.* Mondblindheit; Monatblindheit; periodische Augenentzündung. *Ital.* Oftalmia intermittente or remittente; irido-coroidite recidevante]. In every country this was known as lunatic disease, because for a long time it was believed that its development bore some relation to the phases of the moon and that recurrence was one of its characteristics; it is here called primary because this is almost its only differential character, or at any rate apparently so, the cause from which it originates having a marked predilection for the eye which it exclusively attacks. In short, irido-cyclitis constitutes the whole affection although in its symptomatic form it is only a manifestation of the cause which produces lesions elsewhere.

To explain its development all the favourite causes of old authors have been advanced; the atmosphere, the soil, the weather and the constitution, etc. These perhaps play some part, but only a secondary one. The behaviour of this affection, often enzoötic, has for a long time caused it to be attributed to miasmatic influences, later to parasites and infection, on which theories researches have been recently made.

Parasitic infestation. First of all admitted without proof by Lafosse of Toulouse, Zundel (1875), and Rolland (1890), (rheumatismal monad of Klebs), the parasitic nature of the affection was upheld in 1892 by Willach, after numerous researches made on 37 eyes taken from 24 horses which had been suffering from periodic ophthalmia for longer or shorter periods. Willach so frequently met with parasites either in the softened vitreous humour or in the exudates—varying microscopic parasites (rhabditis oculi equini, filaria, cysticercus oculi equini, distomata, cercaria, etc.), that he had no hesitation in stating them to be the cause of the disease. Small entozoa were never absent from acute lesions; when he did not find them in chronic lesions he explained their absence by their being resorbed.

These parasites Willach also found in uveitis in the ox, and in contagious keratitis of cattle. Schwarznecker and

Baechstaedt have both supported Willach's parasitic theory. At the same time Potapenkow (1892) discovered in the blood of an affected horse an intra-corpuscular parasite similar to that of malaria (?) the intravenous and subcutaneous inoculation of which produced no effects but which when inoculated into the anterior chamber of the horse, dog, and rabbit, in each case produced iritis after a period of incubation of 14–40 days. Lövy, in 1904, also stated his belief in the parasitic theory.

Microbial infection. H. Koch (1882), Trinchera (1889), and Vigezzi (1890), found in the transuded products microorganisms with which they tried to reproduce the affection. Trinchera was able to conclude from his experiments on rabbits and horses that periodic ophthalmia is an infectious disease inoculable to the horse. Vigezzi introducing his ophthalmococcus subcutaneously, subconjunctivally, and intravenously (jugular) obtained no results. By intra-ocular injection he soon caused a purely traumatic affection with panophthalmitis, sometimes a true exudative iritis and the formation of synechiæ; in two cases he had secondary attacks occurring at nine and forty-one days after the first.

In 1898 an enzoötic of periodic ophthalmia occurring in the horses of the 8th Chasseurs at Auxonne attracted attention to this disease and led to new researches being made. Blin (1900) isolated a bacillus which he compared to the bacillus coli; when inoculated into the anterior chamber of the horse it produced symptoms "so closely resembling those of periodic ophthalmia that it might be mistaken for it."

In the tissue of the iris, Dor (1900) found an intracellular diplococcus like the gonococcus, but which in the adult form is clearly bacillary. Its best culture medium is glucose agar. According to Roux and Binet this is the staphylococcus pyogenes aureus. Subconjunctival inoculation of rabbits with this organism does not cause the disease, whilst its inoculation into the vitreous causes first of all a very acute inflammatory reaction, ending in panophthalmitis.

with rupture of the sclerotic. After a study of the virulence of the organism and its modifications, Dor was able to produce at will in horses irido-cyclitis with repeated relapses, which allowed him to demonstrate a treatment before the Lyon's commission (1900). In 1903 Tschoubarowsky, knowing of Dor's work, experimented in the same way and concluded that periodic ophthalmia is due to the presence in the eye attacked of the staphylococcus citreus, albus, and aureus.

Knowing that irido-cyclitis in the horse may be determined by such very varying causes which cannot be distinguished clinically, it may not be unreasonable to conclude that any infective agent, if not of too great virulence, may be capable of determining periodic ophthalmia. For want of more definite evidence it must be concluded that bacterial infection or parasitic infestation seems to be the primary cause of the disease. It may be well now to consider whether this infection takes place exogenously or endogenously, and by what means the infective agent is carried.

Exogenous infection. Krystofowicz and Tschoubarowsky have admitted the possibility of infection taking place from the exterior, through the cornea, but without sufficient evidence.

The experiments of Vigezzi, and those of Dor already mentioned, with regard to attempts at infection by subconjunctival injection proving negative, go to show that this opinion is of little value. There is nothing more to be said regarding this theory of its etiology, except that traumatisms may act on the eye as on other parts of the body so as to awaken a latent infection, or to favour an infection which would otherwise not have been produced. Experiments on animals have proved this predisposing action of traumatisms on the eye, especially in tuberculosis.

Endogenous infection. Endogenous infection by the blood stream seems therefore to be the only admissible method. But the conditions of infection are so complex that it is impossible to say by what means the infection takes place, whether by absorption by the digestive or respiratory tract.

Future researches on this point may determine the means by elimination, and then by prophylaxis it may be possible to prevent this disease, which is a cause of so many horses going blind.

Influence of surroundings. At all times certain localities have been considered as being more favourable than others for the development of periodic ophthalmia. The Government studs at Pompadour suffered greatly from this affection at the commencement of the eighteenth century (Chabert). In 1807, in the neighbourhood of Strasburg, Thierry counted 500 horses blind from "lunatic disease" out of an equine population of 3000. In his treatise *Géographie médicale de la fluxion périodique* (1861) Renaud estimated the proportion at 70 per cent. in the departments of the Somme, Pas-de-Calais, du Nord, and Seine Inférieure.

The following facts particularly prove the influence of surroundings. They are furnished by statistics of the Prussian Army, and are borrowed from Möller: a regiment of Hussars in garrison at Hofgeismar had, from 1871 to 1875, 130 cases of periodic ophthalmia. In 1875 it was sent to Frankfort-on-Maine, and the affection then diminished till in 1880 not a single case could be found in the regiment.

During this period a regiment of Dragoons sent from Frankfort-on-Maine to Hofgeismar to replace them, and which had never before suffered from "Mondblindheit" had cases generally develop as follows: 5 cases in 1876, 12 in 1877, 11 in 1878, 14 in 1879, and 42 in 1880.

Again, the 13th Regiment of Dragoons in garrison at Saint-Avold from 1877 to 1886 had a number of horses affected each year, varying from 2 to 58, the total number of cases being 112, or an average of 11 per annum. In April, 1886, they were sent to Metz, and then only 4 cases were seen through the year, 1 in each of the two following years, and then none. Zundel confirms the enzoötic character of the disease in Lorraine. [According to General Smith it was epizoötic in form during and for some time after the war in South Africa].

Forage and drinking water have each in turn been accused of being the agents by which the infective material is carried. Many observations go to prove that forage from low-lying, marshy land is especially dangerous. In support of this theory there is one experiment of Dor's which may be quoted. A horse fed on forage from marshy lands had a spontaneous attack of "fluxion." Dor reproduced the disease in a rabbit by inoculating into its vitreous humour a few drops of the fluid produced by maceration of the suspected hay in sterile water, while the sterile water injected in the other eye produced no effect.

However, the facts at Auxonne are not in favour of this theory, for whilst the disease severely attacked the military horses, the civilian horses in the town and neighbourhood, which consumed the same food coming from the banks of the Saône, were not attacked. [In the South African outbreak there was nothing in the food supply to explain infection, but there was found reason for thinking that impure water supply was a factor. Nevertheless, where the water was good and abundant the disease was found to exist].

Hugues (1884) in military horses in Belgium has seen the number of cases considerably increased with the distribution of damaged oats, and Reich (1888) in the Caucasus had the same result simply from the substitution of barley for oats (?). In both cases well-marked gastro-intestinal symptoms were also shown.

On the other hand the few data concerning the *rôle* of drinking water leave the matter *sub judice.* Whilst H. Koch has found in the drinking water the agent found in the eyes of animals suffering from periodic ophthalmia, bacteriological analyses made at Auxonne, chiefly by Dor, were negative. Wenzel claims to have seen the disease cease after discontinuing the use of suspected water.

Some striking facts have recently been brought forward by Bigoteau, Rigaux and Enault as to the part played by locality. Bigoteau (1903) states that in a stable of 15 horses receiving, one year with another, 3 new animals from different parts,

there were from 1882 to 1888 always one third of the animals affected. The stable was disinfected, and although the animals previously attacked were kept the new arrivals remained healthy. In 1898 an affected stable became invaded by strangles, which made it necessary for it to be disinfected—this being done with lime. After this there were no fresh cases. [General Smith observes that as to its spreading there can be no doubt. A certain Remount Depôt containing affected horses was broken up, and its horses distributed to two other depôts, in neither of which had the disease been scarcely known. The result was disastrous; 25 per cent. of all the horses in one depôt, and no less than 48 per cent. of those in another, became affected!].

In a stable of 20 horses, in which the proprietor had not seen a case for 15 years, 8 animals were attacked in one year. After disinfection the course of the disease was checked, though two cases were seen later (Rigaux).

Enault saw the disease affecting the young foals on a stud farm in Normandy: 8 cases succeeding one another in six months, the animals being in a shed. On turning them out to grass there were no more cases. Disinfection was as complete as possible, but one more case was seen 15 months after. [In the South African epizoötic dust played no part in spreading the affection; two of the dustiest cantonments escaped. Further, December and January are the wet, and therefore non-dusty months; yet more cases occurred in these two months than any others].

Contagion. Occasionally incriminated, contagion does not seem admissible. In any case there is no sufficient proof. [Capt. Olver, A.V.C., was, in South Africa, unable to convey the disease experimentally by inoculating various diseased products. He, however, considers the malady is conveyed indirectly. This is also General Smith's experience. He says it "cannot be transmitted by any known form of inoculation." (*Vet. Hygiene*, p. 631, 3rd edition, 1905). Dr. Theiler tried every system of inoculation, but signally failed to convey it from animal to animal. The employment of eye fringes to keep off flies was not found to be of *any benefit*].

Heredity. For the most part this is a cause of periodic ophthalmia which is received almost as a dogma. The facts collected by Reynal in 1862 are as much against this cause as for it, and those collected since, especially in Germany, are no more convincing. Moreover, if Reynal was in favour of heredity he meant heredity properly so-called, and considered that this and predisposition are one and the same thing under different names. This is also the opinion of van Dulm, who, observing the disease in the breeding establishments in the Dutch East Indies, does not admit that heredity or contagion but only surroundings play any rôle. Statistics, however, have shown him that the affection is rare in the first year of the life of the foal, and more frequent in the second year, and that the proportion of affected colts is less in those born of affected mothers than in those born of healthy mothers. Besides this, all the etiology at this time amounted to the cause rendering the system susceptible. Further, it is easy to interpret all facts in favour of heredity. An animal born of parents suffering from the disease also becomes subject to it? Heredity seems obvious and is not disputed. Another animal born of the same parents is not attacked. The hereditary predisposition has been overcome by the influence of something which has changed the state of the body—and the theory is saved. [If specific ophthalmia be hereditary, General Smith believes that the infected animals in South Africa were imported with the predisposition in them. Not that every case attacked must have had the ground prepared by hereditary predisposition. The disease spread in the North American horses from hereditary cases to other animals].

Now that everything points to the fact that primary iridocyclitis is an infectious disease the theory of heredity may be dismissed. When animals suffering from the condition give birth to offspring which are not attacked, as has been shown by Mariot-Didieux, heredity is certainly at fault and need not be further discussed. When the offspring are attacked general facts in connection with infectious diseases

allow of the theory of heredity being almost completely rejected, and it may be admitted that the infection of the media is the cause.

Congenital infection. Colts may be born of parents blind from periodic ophthalmia, with acute or chronic lesions of uveitis, nevertheless without heredity being the cause, and the proof of this is that the same thing may occur in animals born of parents perfectly sound in eyes (Möller).

This simply proves that the placental filter is sometimes permeable to infective agents, or in other words that the uterine region may be infected like any other.

Individual influences. Age. The disease develops at all ages and this is all that is known on this subject, as published statistics give no percentages according to ages.

Sex. Here again information is lacking.

External influences. Season. A return for the German Army for the years 1886–1890 (Möller) do not show any difference in total capable of interpretation.

Quarter of year.	1st.	2nd.	3rd.	4th.
	216	197	158	159

Development of the disease. It usually presents itself in a sporadic form, sometimes enzoötically, rarely epizoötically.

Enzoötics have been observed in the Caucasus where, in four regiments of dragoons, the disease attacked 35 % of the horses (Reich) 1889. In Germany it also appeared in different regiments of the Prussian Army. The last enzoötics seen in France were in the 8th Chasseurs [Light Dragoons] at Auxonne, where in the course of the year 1898, 91 cases were seen (Mansis), and in the 26th Dragoons at Beaune in which, from January 1898 to July 1900, 27 cases occurred, although from 1893–1898 only five or six cases were seen (Lenoir and Guillaumin). [According to Castley,* periodic ophthalmia was in the early part of the 19th Century much more frequent towards the north than in the southern parts of Europe. In Spain and Portugal it was a complaint of rare occurrence, whereas in France and England it prevailed to a

* *Veterinarian*, 1831.

considerable extent; but certainly, most of all, in Ireland. Percivall* states that in the Peninsular War asses and mules were more susceptible than horses.† General Smith says, on the authority of Dr. Theiler, that specific ophthalmia was unknown in South Africa before the Boer War. It first appeared in Army horses during the operations in the Transvaal in 1901; by 1902 it had become a scourge. The number of horses affected during hostilities will never be known. During the second year following the war, 1903-04 (after every visible case had been eliminated by casting during 1902-3) there occurred no fewer than 1969 cases of the disease, or 14.38 per cent. per annum of the average strength. More cases were admitted during December and January (the hottest time of the year) than in any other month; during January, 1903, no less than 2.25 per cent. of the total Army horses in the country were affected with the disease! There can be no doubt that the affection was introduced into South Africa from North America and probably Eastern Europe. Such cases were not sent while suffering from the disease: this developed later. The colonial horse and mule were rarely attacked. The imported horse and mule were frequently attacked; the latter came from North America. The following gives the percentage of horses and mules attacked during two years:

	Horses.		Mules.
1903-04,	14.38 per cent.	...	1.85 per cent,
1904-05,	7.11 ,, ,,	...	1.88 ,, ,,

Greenfield has expressed himself in a similar manner. Judging from the abundance of ancient literature upon this malady, it was evidently a very common disease in Great Britain in the 17th and 18th Centuries. Gibson, in his *New Treatise on the Diseases of Horses*, published in 1751, devotes several pages to it. Coleman, at the end of the 18th Century and the beginning of 19th Century, gave it a great

* *Percivall's Hippopathology*, Vol. iii., p. 71, 1858.

† Greenfield, *Vet. Journal*, May and June, 1904.

deal of attention. Since then, probably owing to the better hygienic stabling of horses introduced by Coleman, the disease has gradually declined until now it is, according to Professor Macqueen, rare, both in its acute and chronic forms, in Great Britain. Further, it is now very rarely met with in the Army at home, whereas at one time it was extremely common. Nevertheless, it was a few years ago not rarely encountered in the large Metropolitan Omnibus Companies in the imported North American horses; and according to Shipley, it was increasing in frequency and in dissemination in East Anglia. It is said to be more frequent in Ireland, and probably the few isolated cases seen in hunters, carriage, and other light horses in Great Britain are imported from that Island. General Smith adds, on the authority of Dr. Theiler, that the disease in bovines often confused with specific ophthalmia is in no way related to the horse disease. It was present before the war, and is still very prevalent in certain places, whereas the horse disease is now rarely met with, and only in old horses the survivors of the war period, and in them only in the form of an atrophied eye].

Recurrences. In France, as in other countries, the disease is considered as a specific one, characterised chiefly by its tendency to relapses or recurrences, whence the name of periodic ophthalmia or recurrent irido-cyclitis. But as the ophthalmoscope came into more general use so the characteristics of the affection, recorded with such care by the older observers, became untrustworthy and recurrence only seems to be an infrequent manifestation of the disease.

Reich has recorded that in the Caucasus 35% of the horses were attacked with irido-choroiditis and that of these only 18% suffered from recurrences. Lenoir and Guillaumin followed 27 cases for 18 months with the object of gaining information on this point, and recorded that there was a recurrence in ten cases only.

[The following valuable table, furnished by General Smith, of primary cases and recurrences in horses and mules respectively will prove of great interest; they are taken from ex-

tensive observations, probably the greatest on record, made in South Africa after the Boer war:

Of every 100 admissions for specific ophthalmia during 1904-05.

Horses (636 cases).				Mules (119 cases).			
50.47	per cent.	were	primary cases	75.62	per cent.	were	primary cases.
32.23	,,	,,	second attacks	16.80	,,	,,	second attacks.
11.00	,,	,,	third ,,	3.36	,,	,,	third ,,
4.40	,,	,,	fourth ,,	1.68	,,	,,	fourth ,,
1.10	,,	,,	fifth ,,	1.68	,,	,,	fifth ,,
.62	,,	,,	sixth ,,	.84	,,	,,	sixth ,,
.15	,,	,,	seventh ,,	—			—

Although it is said that all forms of irido-cyclitis are recurrent, the above facts constitute one of the reasons why Nicolas does not use the qualification "periodic," which has the further inconvenience of suggesting a definite period of time separating the relapses (26–30 days according to the promoters of the French laws dealing with defects for which horses may be rejected) (Bernard); nor does he accept the fact of the disease being recurrent in all cases.

Symptomatic Irido-cyclitis. This form of uveitis is usually met with in the course of different infections of the system.

Pulmonary infections. Infectious pneumonias (fiévre typhoïde, pneumonies infectieuses, and pasteurelloses of the French; Brustseuche and Pferdestaupe of the Germans; and contagious pneumonia and influenza of the English) have for a long time been recognised as being liable to produce affections of the eyeball. In Germany especially, numerous investigations have been made on the subject of "iritis" in the course of equine influenza. Whilst in France the vague name of internal ophthalmia has been given to this condition, on the other side of the Rhine a better knowledge of the pathology of the eye has led to a classification of the affections of the uveal tract. But in both countries it has been vainly sought to differentiate, as regards symptoms and lesions, between these conditions and periodic ophthalmia. Nicolas considers internal ophthalmia and periodic ophthalmia as being

irido-cyclitis arising from different causes, but showing the same symptoms.

Nicolas bases his opinion on this point on the result of numerous observations on the horses of the French cavalry and "la Compagnie Génerale des Voitures à Paris," particularly in 1898 in an outbreak of influenza, and claims to have no doubts on the matter. To try to further subdivide these forms would not only be unnecessary but has the inconvenience of confusing the observer and of confounding the pathology with clinical facts.

The uveitis of pulmonary affections has been considered by some authors as not being recurrent (Verheyen, Bouley jun.), while others state that it is less likely to recur than the primary form. As a matter of fact, though we know that irido-cyclitis may have many relapses, as has already been shewn by Hamon and Mariot-Didieux, and as the most recent observations prove (notably those of Mouquet and Guignard, who have studied the disease in the horses of the "Compagnie des Voitures," Vanney, etc.), still the data are not yet sufficient to appreciate numerically the recurrent character of the disease. Nevertheless, the recent researches of Schneider* bring forward a few definite facts on this subject. Ocular metastasis shows itself in .43 per cent. of cases of Brustseuche observed by the author. It appeared in 53 per cent. in the course of the pulmonary affection and 47 per cent. after recovery. In 73 per cent. the eye affection terminated in recovery, and in 27 per cent. it was directly or after recurrences followed by serious complications. Of all the metastases which arose in pulmonary infections irido-cyclitis was the commonest—73.3 per cent.

Amongst other rare causes of the disease must be mentioned strangles (Joly, Nicolas), muscular rheumatism, characterised by fever, a tense condition of the muscles, with pain on pressure and extension, articular crackings at each movement (Möller), and fowl cholera (experimentally produced in the ass) (Lignières). De Haan, in a horse suspected of

* Archiv für Tierheilkunde, Band LIV, p. 55.

glanders, noticed cloudiness of the cornea and a fibrinous deposit in the anterior chamber. On post mortem he found small nodules about the size of a pin's head scattered over the posterior face of the iris. The stroma of the iris, ciliary body, and choroid were infiltrated with smaller nodules and an abundance of leucocytes. Pure cultures of the bacillus mallei were obtained from the nodules.

Tedeschi, in his experiments in 1893, showed that inoculation of the glanders bacillus into the anterior chamber of the dog caused nodules to form in all parts of the eye, including the eyelids, but that the predilection seat seemed to be the uveal tract.

Traumatic Irido-cyclitis. Contrary to our former opinion observations made on the horse have now caused us to admit that, as in man, simple contusions *may* cause symptoms of iritis: exudation in the form of fine filaments, contraction of the pupil, resistance of the iris to the dilatatory action of atropine. The irido-cyclitic reaction *is the rule* in traumatisms even when not accompanied by perforating wounds. Inflammation of the uvea following penetrating operative wounds may keep within the limits of a plastic exudation, but those following accidental perforations of the eyeball almost always suppurate freely and have all the characters of a panophthalmitis. According to Buchs the irritation caused by the presence of filaria in the aqueous humour is sufficient to cause iritis.

Irido-cyclitis from neighbouring suppuration. Suppurative keratitis especially gives rise to this condition. Diffuse choroiditis first localised to the fundus oculi may also extend to the anterior parts of the uvea, as has been seen by Nicolas and Fromaget, Lenoir, and also Guillaumin and Darrou.

Sympathetic or Metastatic Irido-cyclitis. *See* Sympathetic ophthalmia.

Diagnosis of Irido-cyclitis. *Anatomical diagnosis.* This can be made during the acute or chronic phase of the affection.

In the acute phase diagnosis rests upon the following three symptoms, which are rarely incomplete: contraction of the

pupil and resistance of the iris to the action of mydriatics; the presence of exudates or of a deposit in the anterior chamber floating in the aqueous humour and the vitreous, or infiltrating the tissue of the iris and modifying its colour; diminution of ocular tension.

Ciliary and subconjunctival injection should also be looked for.

In the chronic cases diagnosis is chiefly based on the traces of exudates left on the posterior face of the cornea, on the edge of the pupil, or on the face of the iris establishing adhesions between this membrane and other parts, especially with the lens; the condition of the faces of the lens, of the vitreous humour, and of the choroid. If necessary, a few drops of a solution of atropine may be instilled, after which irregular or incomplete dilatation of the pupil may be assumed to be due to the presence of lesions of irido-cyclitis. Atrophy of the eye and its sequelæ: enophthalmos, and "wrinkling" of the eyelids, principally of the upper, will attract attention.

Etiological diagnosis. The lesions of irido-cyclitis are not in any way characteristic of their origin, the only foundation for an etiological diagnosis is to be found in the whole of the circumstances accompanying the development of the disease and its history.

In the acute phase the absence of any well-determined infectious disease, such as pulmonary forms of the pasteurelloses, strangles, glanders, dourine, etc., will allow a diagnosis of *primary irido-cyclitis* to be made.

On the contrary the co-existence of general or local symptoms peculiar to one of the above mentioned diseases may lead to a diagnosis of *symptomatic irido-cyclitis.* In the same way the presence of a wound, superficial or deep, of an ulceration of the cornea or of the scleral region, may give rise to traumatic irido-cyclitis, or irido-cyclitis by extension from a neighbouring lesion.

During the chronic period the visible traces of a wound, of an ulcer of the cornea or of the ciliary region, will allow of a fairly definite diagnosis being made, but the examiner has to

be very careful if the opinion is being given for legal as well as for medical purposes.

Diagnosis from a legal point of view. The French law of the 2nd of August, 1884, in placing periodic ophthalmia among the diseases for which a horse may be rejected was very restrictive.

The legislators wished to protect against a disease which they believed to be especially important on account of its recurrent character, and this is shown by the fact that at the time the law was made there was known to exist two diseases exactly alike as regards symptoms and giving the same pathological characters to the interior of the eye; one, "periodic ophthalmia," was considered as essentially recurrent, and the other, "internal ophthalmia" was admitted not to be so. If the authors of the law wished only to guard against periodic ophthalmia it was because they considered the recurrent character of this disease as being its serious feature. Without recurrence there can be no reason for rejection. This theory has been discussed at length in the *Bulletin de la Société Centrale de Méd. Vét.*, etc. *(Maladies inflammatoires du tractus uveal du cheval)*, 1905; it is not only the sole legal basis, but is not open to arbitration. It is not just, however, for it proceeds from an incomplete knowledge of the diseases of the eye; the only way to remedy it is to alter the law. However this may be, the expert may be able to decide from the actual symptoms, acute or chronic, whether or not the animal is, or has been, the subject of irido-cyclitis; and then to be able to recognise at sight a relapse before rejecting an animal.

Prognosis of Irido-cyclitis. Uveitis is much the most serious affection of the eye of the horse. The majority of cases of blindness or "lost eyes" in this animal support this statement. The prognosis of irido-cyclitis depends in the first place on the gravity of the lesions left by the inflammation, and secondly on the possibility of a relapse or recurrence. The lesions are grave in proportion as they offer a greater or less obstacle to the perception of light, in lesions

of the retina or papilla; or to the transmission of the luminous rays in the case of opacities of the media.

Opacities of the media interfere with vision more or less, according to whether they (*a*) cover a large part of the field of vision, (*b*) are situated near to or far from the retina, (*c*) and in proportion as they become more central. Uveitis in which there is abundant effusion is therefore more serious than that in which there is only a slight outpouring of exudates, and consequently these inflammations can be classified, in the following decreasing order: acute, subacute and insidious.

From the point of view of the possibility of a relapse or recurrence, it must be admitted, until more ample information is forthcoming, that primary irido-cyclitis is most likely to be followed by these developments, and that irido-cyclitis from local causes is the least likely. When produced, relapses have only a relative seriousness, as they add nothing to a complete detachment of the retina or a total cataract resulting from a previous attack as in such cases sight is completely lost; in these cases a second attack only leads to atrophy of the eye, which is appreciable it is true, but only from an æsthetic point of view. Lastly, by adding fresh lesions to lesions of recent date which the system has not yet had time to repair, relapses are more serious to the future condition of the eye than recurrences.

Treatment of Irido-cyclitis. This must be hygienic, prophylactic and therapeutic. The first two of these measures are only applicable to primary irido-cyclitis. We are, as yet, far from the time when it will be possible to say that primary irido-cyclitis is a preventable disease in the same way that glanders can be avoided, but it is quite certain that the epizoötic character which it sometimes shows allows it to be assumed that the disease only develops under favourable mal-hygienic conditions either of the stabling or of the food.

The facts reported by Bigoteau, Rigaux and Enault on this disease should suggest the emptying of buildings, and thorough disinfection of all possibly infective matter, should the affection show any signs of spreading. It may also

happen that certain breeds may lose their supposed susceptibility to the disease by going from their own country to others and so escaping infection (which supports the theory of infection against that of susceptibility). (*Vide* p. 250 for the converse view drawn from South African experience). The disease is sufficiently serious from an economic point of view for efforts to be made in all directions towards its complete annihilation.

Therapeutic Treatment. The horse should be taken from work and placed in a stable as soon as possible. The tendency in the French Army has been to regard affections of the eye as not being sufficiently serious to warrant the patients being sent to an infirmary. At the most they are considered as horses which cannot be used: more often the animals continue to work after being attended to once daily, and the proof of this can be seen in the annual statistics of the French War Office "up to 1902 an average of 130 horses were disposed of on account of blindness, while there is no record of any being received into hospital for treatment for diseases of the eye" (Prévost). A horse attacked with irido-cyclitis is not only an animal which suffers on account of being manifestly unfit for work, and more likely to meet with accidents, but he is also an animal needing more than any other almost incessant care, which can only be given in a hospital. On principle, every horse suffering from irido-cyclitis should be sent into an infirmary. It is also necessary that this should be done at the first sign of lacrimation, as it is especially in slight and abortive cases that a true cure can be obtained, for the treatment of acute irido-cyclitis only consists in what used to be called "washing the eye."

Treatment is local and general.

Local Treatment. The objects of local intervention are to reduce the inflammation and to induce the absorption of exudates; to prevent the formation of adhesions of the iris and relapses.

Atropine alone fulfils almost all these indications: by contracting the iris it diminishes the quantity of blood contained in the vessels and directly lessens hyperæmia; by paralysing the sphincter iridis it puts the membrane in a state of rest; by dilating the pupil it hinders the formation of synechiæ, and tends to break down those already formed; it seems to lengthen the periods between attacks and perhaps may prevent recurrences in certain cases; lastly it raises intra-ocular pressure, which is said to be always lessened in anterior uveitis in the horse.

Cocaine, the action of which in the eye is almost the same, but less powerful, adds to the effect of the atropine as well as relieves the pain. A mixture of atropine and cocaine in equal parts is therefore strongly recommended. It may be employed locally in ointments, instillations or subconjunctival injections.

The action of instillations is less active on account of the movements of the eyelids and of the flow of tears, while ointments remain in the culs-de-sac longer and act over a longer period, and lastly subconjunctival injections are most certain to be absorbed.

Instillations repeated *5–6 times a day* are therefore reserved for subacute and insidious cases.

The following is a suitable collyrium:—

Neutral sulphate of atropine.	
Cocaine hydrochloride	aa. 1
Boiled distilled water	100

[Solutions containing cocaine should not be boiled, as this salt submitted to boiling is precipitated].

In acute inflammations in which the iris is more resistant to the action of mydriatics, an ointment made in the same proportions may be used, or else a few drops of the above solution may be injected subconjunctivally.

Although atropine has the advantage of raising the arterial tension, and has shown itself to be very efficacious in anterior uveitis in the horse, in man it has the disadvantage of causing hypertension in some cases, and if too frequently used may provoke attacks of acute glaucoma. Its use, therefore,

should be carefully watched, and must be guided by the ocular tension. Although hypertony is not much to be feared in the horse, the fact may be borne in mind.

Adrenaline is indicated in all cases alone or in conjunction with cocaine.

Adrenaline solution, 1 : 1000	10 drops.
Cocaine hydrochloride	1/10th gramme.
Boiled distilled water	5 grammes.

Sig. Two or three drops to be instilled two or three times daily.

As an adjuvant bleeding from the angular vein may be tried, being easy to do and only needing disinfection when the flow of blood stops. [Leeches have often a rapid, if temporary, effect in relieving the acuteness of a painful attack].

Blistering with an ointment composed of Mercurial ointment 3 parts, and Cantharides ointment 1 part, at the circumference of the orbit, if the animal can be prevented from rubbing the eye afterwards, always has an appreciable result in lessening hyperæmia and hastening the absorption of exudates.

Both eyes should be shaded from the action of light by a hood, which must exercise no pressure on the edge of the eye affected. [Most practitioners, however, place the animal in a dark box instead of using a hood].

Subconjunctival injections of antiseptics. With the idea of reaching the infectious agent suspected of being the cause of the disease, treatment may include subconjunctival injections of antiseptics which have no derivative action. For example, 1 : 1000 sublimate of mercury, 1 : 200 cyanide of mercury, and 4 : 1000 of biniodide oil (a quarter of a Pravaz syringeful in man, Rollet), have been used in human practice, with the idea of putting the eye in a bath of antiseptic. Nicolas states that the cyanide of mercury seems to have a very marked action on the course of the inflammation; under its influence he has seen exudates very rapidly absorbed, and the pupil freed from synechiæ which would not yield to the action of atropine; but in some cases it does not prevent recurrences. Darrou

has had the same results. The injection of one to three cubic centimetres of a 1 : 200 solution is without danger if the injection is not made too near the edge of the cornea (about 1 cm.), and also if the animal is prevented from rubbing the eye afterwards (by keeping on the pillar reins). The resulting reaction is sometimes so great that bad results may be feared; the upper eyelid becomes hard, œdematous, and swollen, the conjunctiva is infiltrated and may be herniated, and the cornea is slightly cloudy.

Subconjunctival injections of sublimate, quinine, and trichloride of iodine, have yielded no good results in the horse according to Gayewski.

Operative treatment. This includes paracentesis and iridectomy. Paracentesis, by giving exit to the hypopyon and to the aqueous humour, liberates irritant matter from the eye, facilitates the resorption and may lead to a favourable termination. It is simple and presents little danger either in the operation itself or in the sequelæ. The hypopyon may be extracted with fine forceps, as it is often in a sticky mass instead of being liquid.

Möller states that Price* of Cork, in 1841 published an observation on paracentesis accidentally practised on a horse suffering from periodic ophthalmia which put an end to a relapse. Nagel, who often practises the operation without any anæsthesia, Brassi, and Serino all are in favour of this method of treatment. On the other hand, Capt. Olver, who had extensive experience of paracentesis in army horses during the South African War, found the results were more or less unsatisfactory and were not considered sufficiently good to warrant going on with the treatment. In human ophthalmology it is found that iridectomy performed in cases of old-standing iritis, not yielding to atropine and in which there are numerous or extensive adhesions, has the effect of favourably influencing the general nutrition of the eye, of leading to the resorption

* *Veterinarian*, 1841, p. 794.

† *Veterinary Record*, Vol. xxi., 1908-1909, p. 785.

of exudates, and of sometimes lessening the number of recurrences.

In irido-cyclitis in the horse iridectomy seems to have given good results in the hands of Van Bierwliet and Van Rooy, Nagel, Jacobson, and Richter, while Sichel, Peters, Friedberger, Jacobi, Möller, Werner, Dor, and Nicolas have practised it without success.

Internal treatment. By alkalis. This method is based on the biological characters of the causal organism discovered by Dor. Laboratory researches have shown that the growth and virulence of Dor's micro-organism varies with the degree of acidity or alkalinity of the culture medium. His experiments were done in 1900 at the Veterinary School at Lyons, at the instigation of the Minister of War and controlled by a Commission. The cases of uveitis treated were of an experimental nature.

After unsuccessful attempts at controlling the disease by injecting intravenously a solution of bicarbonate of soda (100–120 grammes in 2–3 litres of water) under the conjunctiva (he also used caustic soda 16.5 grammes in 6.5 litres of water) Dor employed iodide of potassium. This agent administered in the same way gave fairly encouraging results, so much so that the Commission gave its opinion that "iodide of potassium is so far the agent which has given the best results from a curative and from a preventive point of view, and it would be well for it to be used in cases of spontaneous ophthalmia, with a view to preventing relapses."

The term "preventive" only aims at experimental uveitis, and cannot be applied to spontaneous cases even to prevent a recurrence, for in order to be effective the preventive inoculations must be made 24 hours before the inoculation with the infective agent.

Iodide of potassium may be administered either intravenously or *per os* in doses determined by Cadéac and Vanney. "The doses to be given each day for about a week (intravenously), should commence with 10 grammes in a one per cent. solution, and being gradually increased should not

exceed 20 grammes. The dose *per os* (a simpler and, as has been shown, as efficacious a method of administration) should at first be 20 grammes daily, gradually increased to 40 grammes; each daily dose should be divided into three or four powders to be given during the 24 hours." (Lesbre, reporter to the Commission).

In spontaneous primary uveitis, iodide of potassium has given good results in isolated cases, according to Duchene, Durand, and Alix.

On the contrary the veterinary report of the German Army for 1902–1903 states that this method is no better than any other. Gayewski arrives at the same conclusion in a statistical report on comparative therapeutics taken from experiments on 32 horses, 10 of which were cured and 22 lost their sight. According to this observer no treatment is efficacious, preventive measures only being of any use. Matthias at the Government Stud at Trakehnen had negative results with iodide of potassium. Vanney and Carlat found by experiments on dogs that the injection of Lugol's solution into the saphena vein (the dose being 10 cc.) hindered the development of uveitis, and as a curative agent had a good effect.

To these methods should be added subcutaneous injections of 30 or 40 cc. of antistreptococcal serum and repeated after forty-eight hours (Hardy), drastic purgatives, and diuretics, which in all cases have the effect of facilitating the resorption of the effusions. Nicolas has given repeated purgatives with the object of evacuating the intestines and preventing relapses; in practice results of this line of treatment do not seem to justify its use. [A good purge to begin with is, however, excellent treatment].

The treatment of irido-cyclitis, symptomatic, traumatic, or caused by inflammation in the neighbourhood, comprises the same indications and the same general methods. Special indications vary with the cause, the action of which must be removed. The elimination of toxins in the major infections, and the removal of foreign bodies, and strict antisepsis in the case of loss of substance of the cornea and sclerotic, etc. As

the existence of sympathetic irido-cyclitis has not been well-established in the horse, recourse to the enucleation of the eye in the hope of saving the other eye should not be made too soon, as advised by Blazekowic and Rolland. [Professor Brusasco, of Turin, advises the following treatment: Potassium iodide and sodium bicarbonate in four-drachm doses given twice daily in the drinking water. A few drops of the following instilled into the conjunctival sac, twice a day: Pot. iodid. 2.5; cocain. hydrochl. 1; glycerin 8; aq. destill. 50. A 3 per cent. solution of potassium iodide should be applied by means of a saturated compress to the eyes. As soon as the intolerance to light and the hyperæsthesia disappear the cocaine is omitted; but the iodide is to be continued. If the eye has been affected for some time and synechiæ have formed, a few drops of a 1 per cent. solution of atropine should be instilled into the conjunctival sac, every three or four hours, until the symptoms have disappeared. This treatment should be continued for four or five weeks. It is said that by these means the disease may be arrested, and even a recovery brought about. Arsenic has been recommended by some authorities for diminishing the number of recurrences; but others have had no good results with it. Sodium salicylate or aspirin in large and repeated doses deserves a trial. For the dissolution of fibrinous adhesions the subcutaneous injections of fibrolysin should be made].

Other Animals.—The Ox.

Nicolas believes (with his friend Th. Clerget) that uveitis is rarely reported in the ox because it is often confounded with epizoötic keratitis. Cases have, however, been reported in France, as in Germany, and Italy, from which it seems that the affection is fairly comparable to that seen in the horse, and was recurrent. [Apparently the specific ophthalmia, which has occurred for many years past as an epizoötic in cattle in South Africa, is of a similar nature, but not identical with, that disease of the horse. *Vide* p. 251]. Willach in 1892 simultaneously observed the disease in a herd of oxen and in

5 horses which were kept on the same estate, and found in the eye of the latter, parasites of the genus *distomum* similar to those described as being responsible for periodic ophthalmia in the horse. Durréchou, Claess and Brouvier have accused the filaria papillosa of being the cause of a recurrent ophthalmia in ruminants. Besides these few records which allow an outline to be made (revisable on occasion) of the varieties of primary irido-cyclitis in the ox, we have also facts derived from experiments and clinical evidence, and more especially from pathological anatomy, including tubercular iritis and tuberculosis of the ciliary body (Nicolas).

Primary Irido-cyclitis. Published observations identify this affection symptomatically with the periodic ophthalmia of the horse. Clerget, having made 15 post-mortem examinations at different stages of the disease, has been able to notice some well-marked differences. The exudate in the anterior chamber has not the dense purulent appearance of hypopyon in the horse; albuminous in appearance, and very often mixed with a greater or less amount of blood, it forms an opaque, slightly dense, chocolate-coloured mass, which remains suspended in the aqueous humour instead of becoming precipitated. If abundant, therefore, it occupies the whole of the anterior chamber, or if scanty it is localised near the pupil. In one case the exudate formed a sort of small lens, situated in front of the pupil and surrounded on all sides by absolutely clear limpid aqueous humour. This globular lens-like form of the aqueous humour has been seen in man in some rare cases in which there was a mass looking very much like a luxated lens (Vennemann).

In the ox everything seems to show that it is derived from the ciliary body in the posterior chamber and that it passes through the pupillary opening; there is first its prepupillary situation, its constant adhesion to the borders of the pupil by fine threads (rarely with the anterior face of the lens), and then its presence on a level with the zonula of Zinn. It may also be met with having the same character in the anterior part of the vitreous humour, and behind the lens.

At the time of resorption and organisation the pre-pupillary exudate is first of all resolved into a floating globular body of fibrinous appearance (for the blood is resorbed), and then into a true whitish membrane which floats within a circumscribed radius, being bound to the edge of the pupil by very thin filaments, which are sometimes met with in the pupillary field. From their form, always more or less the same as that of the pupil (although they may in some cases be in festoons), their situation and adhesions, they may be easily taken for remains of the membrana pupillaris were it not for the tissue of which they are formed, which in no way recalls that of the iris, and their occurrence with some exudation of the iris, or especially of the ciliary body or even of the choroid. In his 15 observations, Clerget in four cases saw albumino-hæmorrhagic exudates of recent origin, four cases of opaque agglomerations in front of the pupil, more dense in appearance and from which the blood had disappeared, and seven cases of pre-pupillary membranes, more or less thick.

Compared with that of the horse this uveitis of the ox is only slightly plastic, for synechiæ are rarely met with. The organised exudates are always discrete; they are especially shown at the surface of the ciliary processes. The vitreous humour remains normal, so also do the volume of the eye and ocular tension. The author has only seen one case in which there was ocular atrophy, with reduction in the cornea, disappearance of the vitreous humour, infundibuliform detachment of the retina, and partial resorption of the opaque lens. This affection has a great tendency to hæmorrhage, and rarely attacks the choroid. Lastly the presence of old and recently formed exudates allows it to be assumed that the disease is recurrent. Briefly stated there is inflammation of the uvea, especially of the ciliary body with a tendency to hæmorrhage but not to the formation of adhesions.

Tubercular Irido-cyclitis. Tubercular infection of the eye is secondary to a focus developed primarily in some other part of the body. This takes place by way of the blood, and particularly affects the uveal tract. Experiments

by direct inoculation in the eyes of rabbits have shown that it does not always extend to whole body and lead to the death of the animal from generalised tuberculosis (Panas, Vassaux, van Duyse).

Experimental Tubercular Iritis. Although experiments have not been made on oxen but on ordinary laboratory animals, their results may here be mentioned to act as landmarks in clinical practice.

Tubercular infection of the iris is first shown by the appearance of an exudate, which is not very characteristic. The nature of the infection is only betrayed by the appearance of pearl grey nodules standing out from the surface of the iris. The cornea becomes cloudy, and is sometimes studded with miliary tubercles. The development of nodules on the iris leads to the formation of tumours invading the surrounding tissues, and may lead to perforation of the cornea. This most often happens at the upper half of the circumference of the margin of the cornea.

Spontaneous Tubercular Iritis. Here the characteristic lesion is the tubercle or nodule which gives the iris a bossellated, leathery appearance, a greyish-yellow colour, due as much to the tuberculous products as to the usually abundant, fibrinous-looking exudate, which, with the other symptoms, bears witness to an intense iritis (Mänleitner).

Sometimes the tubercles, by their union, form actual tufts or grapes, uniting the iris to the cornea; in other cases they form adhesions with the anterior lens capsule (Winter, Spöner). The cornea becomes hazy in all uveal inflammations, which are revealed by the formation of granulations. In developing, the tubercles give rise to invading tuberculous tumours involving all the parts of the eye and presenting, post-mortem, all the specific characters of the disease. Fischœder and Winter have seen them perforate the globe at the sclero-corneal junction.

Nicolas with Walther believes that a more careful examination of the eye than that which is usually practised in Bovines would yield, in some cases, evidence which might be used

with regard to tubercular infection. This has been proved by Spöner, who found on slaughtering an emaciated ox very discrete sphlanchnic lesions, although the eye showed an easily visible caseous mass in the iris which was tubercular in origin.

Among other causes capable of causing symptoms of irido-cyclitis in the ox, malignant catarrh, and suppurative conditions of the cornea and conjunctiva should be mentioned.

Nocard and Léclainche have seen malignant catarrh fairly frequently accompanied by inflammation of the iris.

Moussu has also seen in this affection exudative iritis with synechiæ, intra-ocular hæmorrhages, and loss of sight in the eye.

On the other hand, the close relationship between the iris and the cornea, and the frequency of suppurative keratitis in Bovines seems to cause only rare affections of the anterior part of the uveal tract.

Dog.

Anterior uveitis seems to be somewhat rare in the dog. According to Nocard and Léclainche it is seen in some cases of distemper. Möller has seen two cases of plastic iritis which he attributed to muscular rheumatism. Voss has described a case which for two years showed numerous relapses, each lasting several weeks. Nicolas has found synechiæ in two dogs, but was not able to determine their etiology. [Gray has frequently observed these adhesions; they are, in his experience, generally a result from a former ulceration of the cornea. Iritis, with effusion into the anterior chamber has often been observed by him, not only in the dog, but also in the cat. It also accompanies many cases of parenchymatous keratitis]. [Soffner* has encountered irido-cyclitis in a St. Bernard dressed all over with mercurial ointment]. In experimental Zousfana (Soudanese Trypanosomiasis) in the dog, Rennes saw an iritis develop which caused a deposit in the anterior chamber. Cazalbou has observed the same thing in other trypanosomiases.

* Zeitschrift für Veterinärkunde, Oct. 1904, p. 440.

Cat.

[Hancock and Coats have observed the iris become involved in three cases of tuberculous choroiditis in the cat.* It is, however, far from rare. It may occur as a primary disease of the eye, without any other lesion being discerned in the rest of the body. In some secondary cases tubercle bacilli are not discovered by the microscope].

A cyclitis has been found to develop in monkeys after an inoculation with spirochætes (Ewetzky). It appeared twenty days after inoculation, and the first signs were ciliary injection with turbidity of the aqueous humour and some precipitates on the posterior face of the cornea. The iris appeared normal; no synechiæ were formed. This is, almost exactly, what is observed in serous iritis in man. In experimental rabies in the rabbit, Alfiéri noted as anatomical lesions in the eye, hyperæmia and small hæmorrhages involving the whole of the uveal tract, and especially the ciliary body.

Lesions localised to the Anterior Chamber. *Hæmorrhages.* The anterior chamber may be totally or partially filled with blood. In the first case the corneal field is absolutely red and cannot be illuminated. In the second case there is hyphæma and sometimes clots or filaments which by their direction or situation may put the observer on the track of the seat of the hæmorrhage. The aqueous humour is a little turbid, the pupil contracted and not very sensitive to mydriatics; intra-ocular tension is not diminished, or at any rate not at first. Resorption occurs more or less quickly according to the amount of blood poured out and the cause of its effusion; in twenty-four hours (Kitt), seventeen hours (Arnous), or twelve to fifteen days (Nicolas and Zeissler).

In a dog shown to Nicolas by Demay resorption did not take place, and organisation of the clot led to atrophy of the eye exactly as in uveitis. [Gray has also observed this]. Contusions are reported as causes, and in these cases traces may sometimes be seen on the eyelids and in the subconjunctival tissue in the form of ecchymoses (Kitt in an ox),

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* *Vet, Record*, Vol. xxiii., Jan. 14th, 1911.

corresponding with the seat of the hæmorrhage—this has been noticed in a horse by Nicolas; scorbutus (Arnous), hypertrophy of the left side of the heart (Nicolas and Demay) in the dog; pleuro-pneumonia in a horse (Zeissler), and in this case there was hæmorrhage first in the right and then in the left eye. [It has also been seen in the horse in purpura hæmorrhagica].

Iridectomy is almost certain to cause hæmorrhage in the horse and dog. Lastly, it has been seen in perforation of the cornea followed by a rapid escape of the aqueous humour, *i.e.*, a rapid lowering of pressure may be sufficient to cause it. Treatment consists in instillations of adrenaline to check the hæmorrhage if necessary; of atropine to prevent adhesions of the iris, together with the internal administration of purgatives and diuretics to favour resorption, which in some cases, however, occurs without treatment.

Choroiditis or Posterior Uveitis. *Clinical forms in the horse.* As has already been seen the inflammation often extends from the anterior to the posterior segment of the uvea, to cause irido-cyclitis, and the symptoms by which the participation of the choroid can be recognised have already been given (Nicolas). The primary inflammations localised to the choroid are particularly interesting on account of the fact that they are developed without external reaction, and sometimes have a very serious effect on the sight. The study of choroiditis belongs exclusively to the domain of ophthalmoscopy; it is only seen if looked for, and this is the reason why ophthalmoscopic examination is imperative for the examination of all horses bought for the Army [and, in fact, for saddle-work].

However, these primary inflammations may attract attention when they have extended to the anterior segment of the uvea or have led to blindness through atrophy of the optic disc.

According to its anatomical form or the period of its evolution, choroiditis is exudative, plastic, or atrophic. According to its ophthalmoscopic form it is discrete, or circumscribed in small disseminate patches.

Diffuse Choroiditis. This, at its commencement, is characterised by exudation which spreads over the whole surface of the choroid, giving the different regions of the fundus oculi a uniform, dull, dirty yellow tint which is easily differentiated from the brilliant yellow colour which is normal to certain tapeta. The ocellated blue or green points of the tapetum appear blurred or even disappear completely under the exudate. The retina is raised in places so that these parts can be recognised by the difference in refraction existing between them and the surrounding parts. The papilla is also blurred. No diagnostic value can be assigned to the great redness of the fundus oculi, which has been regarded by some observers as a symptom of congestion of the choroid. Congestion of the choroid cannot be recognised in animals possessing a tapetum, as this membrane is too opaque to allow of any change being seen. The redness of the fundus oculi, situated round the papilla in the median line of the tapetum, seen in certain cases, is a congenital anomaly. (*See* pp. 96–100 and plate iv., fig. 2).

At a later stage the effusion is resorbed and produces some disorder in the distribution of the retinal pigment or, in becoming organised forms white patches or streaks which lead to choroidal atrophy, and sometimes even to detachment of the retina. (*See* plate v.).

At the same time that these changes are produced in the appearance of the choroid, it is not rare to see the papilla become blanched; the vessels of the retina diminish in calibre and this ends in atrophy of the optic nerve. This form is comparatively rare compared with the relative frequency of disseminated choroiditis, but on the other hand it is proportionately serious, one reason being that it may spread to the anterior segment of the eye and give rise to irido-choroiditis, and the other being that it is almost certain to lead to atrophy of the papilla, and consequently to blindness in the eye attacked.

Disseminated Choroiditis. Instead of being spread diffusely over the whole of the choroid the inflammation is

circumscribed in small patches. According to the evolution of the inflammation, or its termination, three forms can be distinguished:

Exudative form. The exudative foci are uniform in colour, whitish or yellowish white, about the size, by the erect image, of flax seed, or up to a small shirt button, but their borders are ill defined; they may be better compared to greasy spots on a black ground, for they are almost constantly situated in the

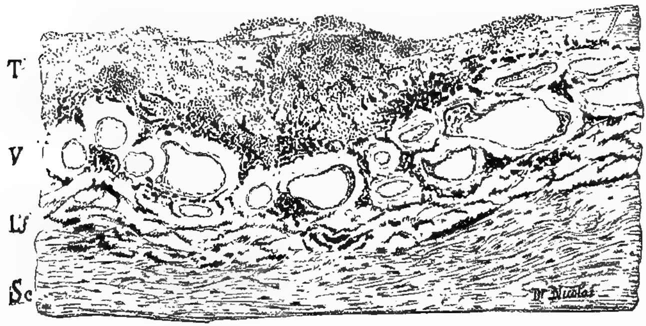


Fig. 91.—Exudative choroiditis (horse).
T. The tapetum. *V.* Layer of large vessels. *Lf.* Lamina fusca. *Sc.* Sclerotic.

tapetum nigrum, below and at the side of the papilla, rarely above it. As a rule they are quite isolated from one another, but may sometimes be confluent. The vessels of the retina pass over their surface, thus showing the subretinal seat of the exudate. (Plate vi., fig. 1).

Post-mortem, the foci of disseminated choroiditis are about the size of a pin's head.

This form which has been especially recognised by Nicolas does not last very long, about three weeks, according to Bidault, which may explain why they are so often unnoticed and have been ignored by other authors.

Atrophic form. The exudate is resorbed causing a displacement of the retinal and choroidal pigment.

The size of the patches is about the same as in the preceding case, but their margins are better defined. Their depths are uniform in colour, pearly white, reddish, or greyish blue, or they sometimes show a black spot in the centre, or in still other cases they may have a red streak denoting the presence of a choroidal vessel. They are rarely single; 20 or 30 may be counted, or even more, grouped in a semicircle round the papilla or forming figures in front of or behind it. (Plate vi., fig. 2). In certain more rare cases small irregular white points may be seen, once or twice the size of a pin's head, joined together near the papillary border forming varied designs; the eye looks as if it had been pierced like a colander to allow a white membrane to appear behind.

Peripapillary form. In this case there are large patches which may be in contact with the papilla in its whole circumference, but more frequently situated in the tapetum nigrum. Their margins are ringed, the base is white here, grey there, bluish, or reddish, elsewhere, dotted with little islets of pigment and crossed by ill-defined red streaks, which are choroidal vessels. The retinal vessels pass over their surface without any apparent deviation. (Plate vii., fig. 2).

This peripapillary form sometimes results from the fusion of separate circumscribed patches of exudation (or apparently does so). It is then a termination of the preceding form. But it is possible that it may be a choroidal metastasis from irido-ciliary inflammation, for it frequently coincides with traces of anterior uveitis. Bayer, who has described peripapillary choroiditis in his *Atlas*, thinks that it has some connection with periodic ophthalmia.

From its situation and appearance peripapillary choroiditis has been considered as analogous to posterior sclero-choroiditis of man. But besides these lesions of the choroid which exist in the horse nothing else seems to justify this comparison. There is no high degree of myopia, no ectasia of the sclerotic—characters which are symptomatic of this affection in man.

In 1863 the ophthalmologist, van Bierwliet and van Rooy, a veterinary surgeon, wrote about peripapillary lesions in horses which they identified with pigmentary retinitis in man on account of the distribution of the pigment. Reading their observations, it seems evident that they were mistaken as to the nature of the affection observed, and that they were in reality dealing with that form of choroiditis which we now call peripapillary (*See* Retinitis).

Nicolas, having histologically examined several cases of this form of choroiditis, has been able to make out the following lesions, which are all the more striking when they are compared with the surrounding healthy parts: The choroid is manifestly atrophied, and thinner; its vessels which being flattened have, so to speak, no longer any walls, or are reduced to the tunica interna; the lamina fusca has disappeared in places and the choroid seems more intimately united to the sclerotic; the pigment in place of being gathered round the vessels is collected into masses, which mask the structures underneath them. Further, here and there, near the vessels are seen nests of round cells which stain deeply with aniline dyes.

The corresponding portion of the retina shows alterations which are much more easy to recognise, consisting especially in a more or less complete disorganisation. The external molecular layer, more vividly coloured by hæmatoxylin than the internal, seems to disappear, whilst the internal molecular layer, of which the molecules, at points, seem to be increased in number, spreads out almost uniformly between the layer of nerve fibres and the membrana limitans externa. There is also pigmentary infiltration, but without any fixed distribution. The rods and cones are destroyed, and in places adhesion of the retina to the choroid can be seen to have taken place through the intervention of a fibrillary substance. Were it not for the persistence of healthy parts which have retained their structure sufficiently to be recognisable as portions of

the retina, some of these parts might be taken for a membrane of inflammatory origin (Fig. 92),

Little is known of the *causes* of choroiditis. It is probable that they are not very different to those causing inflammations of the iris and ciliary body. The participation of the choroid in affections of the anterior segment of the uvea, and the spread of diffuse choroiditis to the ciliary body and the iris, and lastly the frequent coincidence of chronic alterations of these organs with peripapillary choroiditis, are facts which

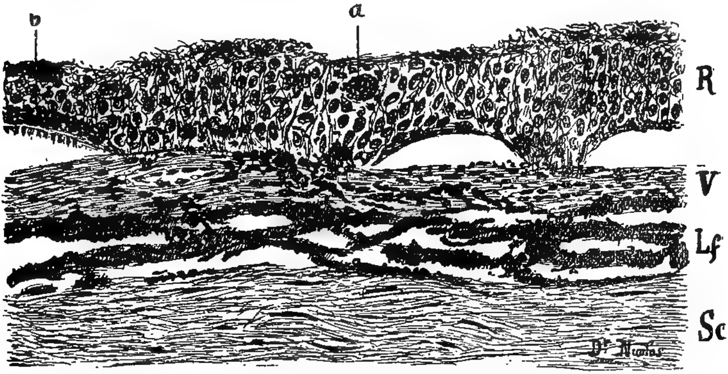


Fig. 92. Atrophic peripapillary chorio-retinitis of the horse.

R, The retina adherent at two points to the choroid; still showing the external molecular layer, and the layer of rods and cones at *b*; and a ganglion cell *a*. *V*, The vascular layer of the choroid, the vessels of which are scarcely recognisable. *Lf*, The lamina fusca, the tracts of which are infiltrated with pigment.

are worth bearing in mind. Regarding inflammations of the uveal tract therefore, it seems that different causes may give rise to them, but that the same cause may, according to the intensity of its action and certain other conditions which are difficult to determine, produce lesions in different situations which can be recognised clinically. [It is commonly encountered in horses kept for a long period in coal-mines].

The *diagnosis* of choroiditis is easy.

Prognosis varies. Diffuse choroiditis is a serious condition for the reasons given above.

On the contrary, disseminated choroiditis is a benign affection apparently not accompanied by any appreciable ill-effects on the visual function, without doubt because it is localised to the region below the papilla. Rémond has, however, published a case of atrophy of the papilla which he attributed to a co-existing peripapillary choroiditis. Nicolas considers that there is not sufficient evidence to associate "shying" in horses with this affection.

Treatment. Little can be done to check the progress of choroiditis. However, some attempt should be made in the diffuse form to increase resorption of the exudates; repeated purgatives, diuretics, alteratives, etc., to check the course of the affection and its propagation in a forward direction; bleeding from the angular vein, subconjunctival injections of antiseptics, and putting the iris in a defensive position by means of atropine—all these measures are indicated.

Tubercular Choroiditis. By injecting tubercular material under the meninges of experimental animals Deutschmann has obtained a miliary eruption on the choroid. There was also developed an *induced papillo-neuritis* and optic atrophy which the author considered as due to the inflammatory action of the bacillary products.

Spontaneous tubercular choroiditis is not absolutely rare in animals, according to Manleitner, who states that it occurs in about 60 per cent. of cases of ocular tuberculosis, and this may be seen in the ox in about 5 per cent. of cases of generalised tuberculosis, and in 1.5 per cent. in the pig. But it does not seem to have been made the subject of any ophthalmoscopic description. It is only as a post mortem lesion that it has been recognised; von Graefe described the first case in a pig in 1858. The tubercles may be isolated, but more often the miliary granulations form by their union a layer of exudation, the surface of which is uneven, accom-

panied by a fibrinous deposit raising up or penetrating the retina (von Graefe, Hess).

They may be collected into nodules which, situated between the choroid and the sclerotic, fold these membranes one on the other (von Graefe, Winter). Ripke and others have described actual tubercular tumours developed in the choroid and invading and disorganising the eye in the same way as neoplasms of the same size.

[Tubercular choroiditis is somewhat common in the cat, and not a rarity in the dog. Attention is usually drawn to it by the loss of sight and the amaurotic condition of the pupil. In the majority of cases both eyes are affected. It generally produces detachment of the retina, some retinal hæmorrhage and a tortuous appearance of the retinal vessels. As the disease advances the whole eye becomes involved. In most instances the process is only secondary to lesions in other parts of the system. The loss of sight and the amaurotic state of the pupil may precede ophthalmoscopic changes in the fundus.

Quite recently Hancock and Coats* have well studied and clearly described this affection occurring in six cats brought to their notice by Sewell. In one animal there were no other lesions in the system beyond those confined to the eyes. Most of the animals were young and seemed in good condition. In one case the right eyeball became enlarged (buthalmic). In some there was retinal detachment, vascularisation of the cornea, and some iritis; in two cases the corneo-iridal angle was effaced. According to Sewell it is *always* accompanied by hyperthermia †].

Functional disturbance of the Iris. The facts relating to the pupillary reflexes having been dealt with under the heading of methods of examination of the eye (p. 88), it is here only necessary to consider modification in the dimensions of the pupil. It must be remembered that these dimensions

* *Veterinary Record*, Vol. xxiii., pp. 433-6, Jan. 14th, 1911.

† Unpublished communication.

vary physiologically within fairly wide limits, from different causes; the pupil is larger in youth than in old age, and in a feeble light than in one more intense. Further, in order to avoid errors it is necessary that the eyes be equally illuminated at the moment at which the examination is made. It is therefore only after a careful examination that an opinion as to the dilatation or contraction of the pupil can be given, at any rate when both eyes are equally altered, for when the change is unilateral the inequality is obvious.

Inequality of the size of the pupil, or *anisocoria*, is always of pathological origin. Pathological variations in the size of the pupils are occasionally symptomatic of local alterations, but are more often extra-ocular. The following observations regarding mydriasis and miosis are borrowed from Berger.

Mydriasis. Increase in the size of the pupillary diameter or mydriasis results from paralysis of the sphincter muscle of the pupil, or from a state of spasm of the dilator of the pupil from stimulation of the cervical sympathetic. It may be unilateral or bilateral.

Unilateral mydriasis. Attention must first be directed to the question of the instillation of a mydriatic, such as atropine duboisine, homatropine, cocaine, hyoscyamine, hyoscine. In these cases, if the instillation is recent, the dilatation is at a maximum. It decreases during the following days and disappears about the sixth to the tenth day, according to the strength of the solution.

Contusions or traumatisms of the eyeball or the regions bordering on the orbit also give rise to mydriasis less marked than in the preceding variety but persisting longer (a month or even more); the photo-motor reflexes are as a rule preserved.

These causes act by their effects on the muscular protoplasm of the pupillary sphincter and cause paralysis.

But this may also arise from changes in the common oculo-motor nerve; traumatisms, neoplasmata, inflammatory products, may any of them act on a portion of this nerve, either in its orbital or intra-cranial course or in the pons

Varolii. If there is complete paralysis of the third pair, other concomitant symptoms will be added to the dilatation of the pupil; drooping of the upper eyelid, external strabismus, immobility of the pupil, and then the lesion is most probably outside the pons Varolii (extra-protuberantial). But it may also happen that the only symptom shown is dilatation of the pupil, and in this case the seat of the lesion is most often near the nuclear centres.

Contrary to what is commonly believed, unilateral blindness is not accompanied by mydriasis. [Monolateral mydriasis is often seen in the dog suffering from cerebral tuberculosis, chronic epilepsy, or from hysteria].

Bilateral mydriasis. In every case of complete blindness in consequence of a non-cortical lesion, such as alterations in the retina, in the optic nerves, in the chiasma, in the optic tracts, consequently in the centripetal pupillary fibres, there is also bilateral mydriasis and absence of reflex to light.

On the contrary, in cases of cortical blindness from a vascular or other lesion of the occipital lobes, the pupils keep their normal diameters and react to the stimulus of light. (*See* Fig. 53, p. 91).

Bilateral mydriasis, with partial or complete persistence of the power of vision, may perhaps arise from the action of mydriatics instilled into both eyes or given internally or subcutaneously; from bilateral paralysis of the third pair of nerves; poisoning *via* the alimentary tract by strychnine or curare [?]; intestinal worms; lesions of the central nervous system, such as meningitis of tuberculous or other origin; abscess of the brain; [and during or soon after an attack of epilepsy in the dog. In the later stages of chloroform anæsthesia, and of poisoning from opium, veronal, chloralose, etc., it is frequently seen].

Miosis. Constriction of the pupil, or miosis, is the effect of an active contraction of the sphincter muscle by a stimulation of the fibres of the common oculo-motor nerve or from a paralysis of the dilator supplied by the cervical sympathetic.

The cause may first of all be looked for in *alterations in the vicinity;* erosions or ulcers of the cornea; superficial foreign bodies on this membrane; hyperæmia or inflammation of the iris; then in the action of miotics such as [arecoline], pilocarpine, and more especially eserine instillations. These possibilities being dismissed, attention will be given to paralysis of the cervical sympathetic, which will be shown by accompanying symptoms—drooping of the upper eyelid, enophthalmos, hypotony. Further, the pupil contracts in the light, is constricted by eserine, dilated by atropine, and not affected by cocaine (Donath). In man it is probable that the miosis seen in certain affections of the cervical lymphatic glands, degeneration of the thyroid, mediastinal tumours, sometimes bronchial or pleuro-pneumonic affections can be referred.

Mention must also be made of the miosis produced by poisoning by morphia, opium, tobacco, aconite, veronal, [chloralose] chloral and chloroform during the period of anæsthesia. "When in an animal in a state of coma miosis is observed in place of the usual mydriasis, it may be taken as a sign that the miosis is produced by the absorbtion of morphia or opium" (Berger). Meningitis and spinal affections also determine it. [Blows on the eye, and certain cases of discission in the dog have been followed by complete miosis].

Trembling of the Iris (Iridodonesis). When the iris is no longer supported at its pupillary margin by the lens it oscillates like a piece of thin fabric [or a curtain hanging at an open window] in a slight breeze. The undulations are very feeble, but having once been recognised are easily detected in a fresh case. This is also a symptom of subluxation or luxation of the lens. [Gray has observed the irides to move clonically or twitch in certain cases of cerebral chorea, following distemper in the dog].

Solutions of Continuity of the Iris, of the Ciliary Body and Choroid. Iridodialysis. (*Separation of the iris*). By this term is meant a detachment of the iris from its corneal or ciliary insertion. Although this alteration has not been noticed in animals—or not as a spontaneous lesion (for

Forster has experimentally determined it by contusions of the centre of cornea), a rapid sketch of the condition may here be given in order that it may not be confounded with zonulo-dialysis or tearing of the fibres of the zonula of Zinn. [It has, however, been encountered in the cat, dog and horse; it has resulted from blows, lacerations of the cornea by cat scratches, or running against sharp projections].

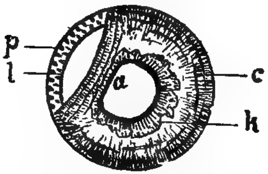


Fig. 93.—Iridodialysis in man (Fuchs). *a*, Deformed pupil. *c*, Circles of contraction of the iris. *l*, Equator of the lens. *p*, Ciliary processes.

Iridodialysis is recognised by disfigurement of the pupil and an accidental opening existing at some point of the periphery of the iris (see fig. 93). Through this opening can be seen the lower border of the ciliary processes, the fibres of the zonula of Zinn and the equator of the lens; the fundus oculi may also be examined through this aperture.

As two pupils exist there are two images of objects on the retina (*monocular diplopia*).

It may happen that the iris is completely torn away and falls to the bottom of the anterior chamber, where it forms a small shrunken mass (*aniridia*). Iridodialysis in man is most often the result of contusions of the eyeball. [Gray has encountered it in the cat and dog, due to the claws entering the anterior chamber and reaching the iris during fighting].

Wounds of the Iris. These have, as a rule, the effect of producing one or more supplementary pupils. They may be *accidental* and are then the same, as regards shape and situation, as the wound of the eyeball resulting from the passage of the pointed or cutting instrument which was the primary cause; or else they are *surgical* (iridectomy), and in these cases they are situated at the periphery of the iris, and the wound of the eyeball is linear and situated near the sclero-corneal limbus.

Wounds and Ruptures of the Choroid. The only information on these points is the result of experiments on horses by Bayer and on rabbits by Berlin. By puncturing the tapetum of a horse by means of a curved needle, Bayer obtained an ophthalmoscopic image described as follows: In the centre was a white spot representing the sclera bounded by the hæmorrhagic and pigmented borders of the wound in the choroid. The hæmorrhage was continued under the retina, some distance from the wound. Contusions of the eye of a rabbit produced by means of an elastic band, caused, besides the lesions of the retina at the point struck and in the region directly opposite, hæmorrhages which were mostly subchoroidal, but sometimes subretinal, and visible with the ophthalmoscope. In some cases the effects of the blow were sufficient to cause rupture of the choroid at the point directly struck.

When the blow was made on the cornea, besides the choroidal hæmorrhages of the deeper parts there were also small hæmorrhages in the ciliary region.

Tumours of the Uveal Tract. With the exception of tuberculous lesions, which are not rare in the ox, pig [and cat], as has been mentioned in dealing with tubercular iritis and choroiditis, other tumours (neoplasms) are rarely reported in animals. Bayer has met with sarcoma in the eye of the horse, as have Kitt and Hess; enchondroma by Renner. Nicolas once saw on the anterior face of the iris of a horse a tumour, cystic in appearance, about the size of a pea, the external covering of which resembled the neighbouring tissue. It in no way hindered the functions of the eye, which were absolutely normal. It did not develop any further. Bayer records a similar case seen post-mortem on the posterior face of the iris of a horse.

According to their situation they provoke varying lesions when they reach a certain size. Starting in the iris or ciliary body, they invade the anterior chamber or the vitreous humour, luxate the lens (Kitt), compress it and cause it to undergo atrophy (Hess), and may even make a way for

themselves to the sclero-corneal junction. If their origin is in the choroid they raise up the retina, and push it before them, leading to atrophy of the vitreous humour, and a time arrives when they appear in the field of the pupil, giving it a greyish blue colouration.

In man the phenomena of amblyopia are often the first to attract attention; later, pain and increased tension.

When new growths of the uveal tract take an invading course excision of the eyeball is indicated.

Congenital Anomalies of the Uveal Tract. Persistence of the Pupillary Membrane. In the development of the eye, as has been stated, the anterior chamber is formed by the cleavage of a tissue which separates into two membranes; one, anterior and thick, forms the stroma of the cornea; the other, posterior, very thin and vascular, clinging to the anterior face of the iris, the pupillary opening of which it obstructs, is the pupillary membrane. This membrane, which is only a fœtal structure, disappears at birth in normal cases, also in animals which have their eyes open at birth, as well as those which have them closed, as Nicolas has several times seen in puppies.

Persistence of this membrane constitutes an anomaly observed in the horse by Gürlt, Schindelka, Schimmel, Möller; in the ox by Meyer; in dogs by [Youatt], Möller and Le Calvé (Figs. 94 and 95); in the rabbit by Mayerhausen. Some remarkable cases have been described in man (Fig. 96).

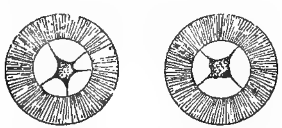


Fig. 94. Pupillary membranes in the dog (Le Calvé).

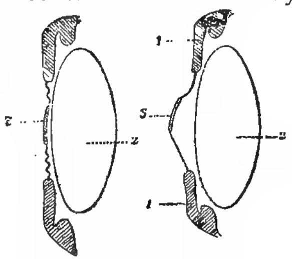


Fig. 95. Seen in section.

The membrane is rarely complete, being sometimes reduced to a thread. Its tissue, exceptionally white (Meyer, Le Calvé),

as a rule recalls that of the iris by its brown or grey colour; on account of its elasticity, neither the membrane nor the thread completely stops the movements of the pupil or its dilatation by mydriatics; and from the presence of vessels which are visible with a hand lens (Le Calvé). Its *attachment to the anterior face of the iris*, considered as characteristic, does not seem to have attracted the attention of every observer; Le Calvé has demonstrated a pupillary membrane

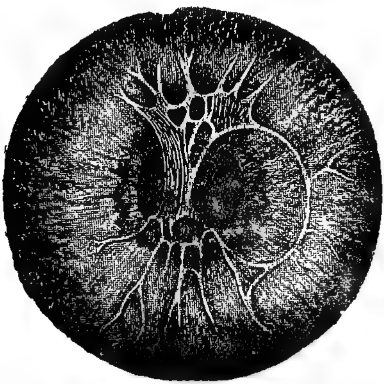


Fig. 96. Pupillary membrane in man
(Van Duyse, Encycl. Franç. d'Ophtalm.).

(It is attached by its peripheral filaments to the anterior face of the iris).

fixed to the border of the pupil by fine threads, a condition which is rarely presented. "The characteristics allowing a distinction to be made between traces of the pupillary membrane, and pathological products due to inflammation of the iris are found in the fact that the filaments always start from the anterior face of the iris, mostly from the region of the smaller circumference, and not from the border of the pupil. They may also arise from the middle zone of the peripheral extremity of the ciliary portion" (van Duyse). In their central parts the filaments or patches are free or adherent to the anterior lens-capsule.

The pupillary membrane may embarrass the power of vision to a degree varying with its dimensions and its position in the pupillary field. The dog described by Le Calvé hesitated in its walk, blundered into obstacles, and could only see indistinctly in a badly-lighted room; without doubt this was because the membrane was sufficiently large to completely obstruct the pupil, contracted under the influence of a bright light, while in dark places the peripheral parts of the pupil allowed a certain amount of vision. It was in fact an easily explained case of nyctalopia [day-blindness]. This malformation is transmitted hereditarily and often co-exists with other congenital anomalies. The dam of the dog described by Le Calvé showed the same deformity, and gave birth to two litters of puppies, sired by different dogs, showing ocular malformations. [Youatt has observed a case in a dog eight months old in which the persistent pupillary membrane had disappeared six months later].

Hereditary transmission is a fact which is fairly general for all congenital malformations of the eye. There is less a heredity of a particular malformation than a predisposition to an anomaly; congenital anomalies of the eye are about equal as regards frequency of transmission.

The diagnosis has to be made from *pupillary membranes of inflammatory origin* which, as has already been mentioned, are not rare in the ox, and from synechiæ when the traces of the pupillary membrane take the form of filaments adherent to the anterior capsule of the lens.

Treatment. It is possible that the pupillary membrane may disappear, [as in Youatt's case], by resorption, but this rarely happens. Meyer has seen this occur in two months in a calf nine months old. In cases in which the interference with vision affects the utility of the animal, ablation is indicated.

Coloboma of the Uveal Tract. This term which properly means "maimed" signifies a condition in which there is a solution of continuity in the organ under consideration. The eye in its development allowing of a median, inferior fœtal cleft, the non-coaptation of the margins of this cleft

(which is exclusively concerned with the retina), is betrayed by a coloboma of the retina and optic nerve, and consequently of the uveal tract; the sclerotic is rarely fissured; but the vitreous humour and the lens may be secondarily attacked like the choroid. This is the *typical coloboma* which is easily recognised on account of its median situation in the inferior hemisphere.

Clinical observations furnish other colobomata situated in every meridian of the eye; these are *atypical colobomata* which may be caused by intra-uterine inflammation producing an arrest in the development of, or an atrophy of the eye. However, van Duyse saw in an embryo of a cow, a double fœtal ocular cleft, one typical, the other atypical, and this allows it to be concluded that some atypical colobomata are due to the existence of accessory fœtal clefts.

Coloboma of the Iris. This has been observed by Leblanc, Gurlt, Hering, Bayer and Renner in the horse; in the ox

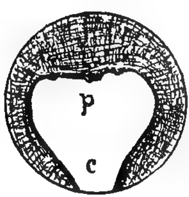


Fig. 97. Typical, total coloboma of the iris in a calf (Keil). *p*, Pupil. *c*, Coloboma.

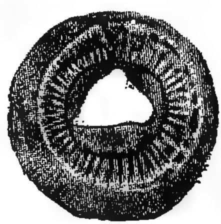


Fig. 98. Three atypical partial colobomata of the iris of a pig. (Bock, Encycl. Franç. d'Ophtalm.).

and calf by von Ammon and Keil; in the dog by [Gray], Heyfelder, Möller and Vachetta; in the pig by Bock and Dochtermann; in sheep by von Ammon; and also in the fowl (von Ammon). The cleft is found in the pupillary margin, which is more or less notched, according to whether the iris is divided only partially or in its whole thickness.

There may be one or several clefts; Bock saw three colobomata dividing the iris of a pig (fig. 98).

If the cleft does not involve the pupillary margin it forms one or several accessory pupils; this condition is called *polycoria*. Up to twelve have been counted in man. [Gray

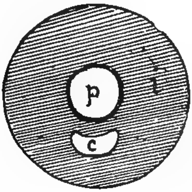


Fig. 99. Partial typical coloboma of the iris of a dog (polycoria), (after Möller).

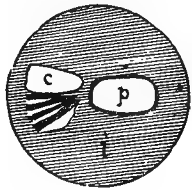
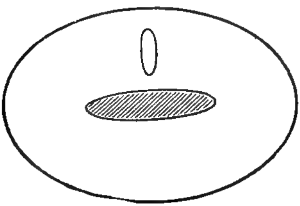


Fig. 100. Partial atypical colobomata of the iris of a horse, (after Hering).

has in the dog encountered an isolated small coloboma, scarcely, or not at all noticeable when the pupil was dilated; but when contracted, a small orifice near the free pupillary margin was observable. Gen. Smith has, in the horse, met on several occasions a vertical slit in the centre of the upper part of the iris. It did not seem to affect vision]. Coloboma of the iris may cause defective vision, from blurring, if the pupil is large and does not contract well, or else by *diplopia* (double images), or *polyopia* (multiple images) if there is polycoria.



Coloboma of the Ciliary Body. This form is much less frequently seen and is usually a post-mortem discovery. Bock has seen it in a pig where it co-existed with a coloboma of the iris, and another of the choroid (fig. 101).

Ciliary coloboma is constant in the eyes of Cochin China fowls, and is characteristic of the breed (van Duyse).

Coloboma of the Choroid. A fissure of the choroid rarely extends throughout the whole of this membrane. When it

exists beneath the papilla (subpapillary coloboma) it is sometimes prolonged into the papilla itself (coloboma of the papilla). This has been seen in the ewe by von Ammon, and in rabbits by Ginsberg and Manz. Subpapillary coloboma has been met with by von Hippel in a male rabbit, whose descendants were affected in the same way to the number of 28 out of 112 eyes. Renner and Nicolas in the horse, Zimmermann in the dog, Bock and Dochtermann in the pig, Hess and Terrien in the rabbit, have found more or less extensive colobomata of the choroid.

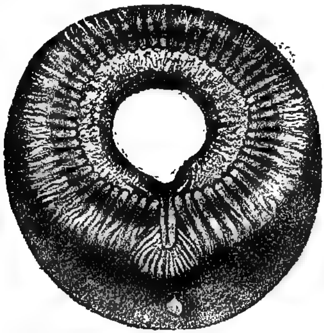


Fig. 101. Ciliary zone of the eye of a pig (Bock).

A partial coloboma of the iris, a complete one of the ciliary body, and a minute fissure in the choroid (Encycl. Franç. d'Ophtalm.)

The condition may be diagnosed with an ophthalmoscope. At the place where the coloboma exists, the choroid, being deficient, allows the bluish-white tint af the sclerotic to be seen, and some vessels running over its surface. The borders of the coloboma are often limited by a deposit of pigment.

This anomaly is almost always accompanied by coloboma of the retina or some alteration of this membrane. It also causes defects of vision such as blurring of the image, amblyopia, and sometimes nystagmus. It is also stated that in man, eyes which are affected with coloboma are easily attacked by inflammation and disturbance of nutrition (van Duyse).

In the horse there very frequently exists a partial coloboma of the choroid often noticeable in the middle part of the tapetum lucidum, the fundamental layer of which is lacking; this is called by Berlin *coloboma of the tapetum*. It is manifested by a reddish colour from the layer of vessels of the choroid being visible (*See* Plate IV., Fig. 2). This form does not cause any disturbance of vision. These colobomata are frequently associated with microphthalmos as well as with other malformations of the eye. An observation by Dochtermann on the pig shows this character of association very well; a boar being allowed to cover four sows—own sisters to himself—sixty-four blind young pigs were born showing colobomata, microphthalmos, aniridia, cataract and even cranial deformities. The eyes of the parents were healthy. Hereditary transmission is frequently reported.

Aniridia. This means complete absence of the iris (also called *irideremia*). It is congenital and is often accompanied by other anomalies. Dochtermann has seen it in a pig and Vachetta in a cat, which suffered great inconvenience from the dazzling effect of the entry of too many rays of light. It may be traumatic in origin; in such cases as has usually been observed in man, some trace of the iris can, as a rule, be found in the anterior chamber. Ophthalmologists remedy this defect by means of spectacles fitted with a moveable iris-diaphragm.

Hyperplasia of the Corpora Nigra. Pigmentary herniæ [or ectropiæ] of the margins of the iris, rare in the human subject, are so constantly seen in some animals [especially in the Herbivora] as to constitute a physiological condition. Excessive development of these bodies, in rare cases, has been accused of causing amblyopia especially in a bright light which would cause contraction of the pupil (Stockfleth, Pallin,* Serafini, Schindelka, Vachetta).

At the urgent request of the owner of a valuable race-horse, Professor Eversbusch attempted the removal of the

* Three cases reported in *Veterinary Journal*, Vol. xxi., p. 313, 1885.

corpora nigra which were considerably enlarged—being about two centimetres in their horizontal diameter and one in the vertical, completely covering the pupil in its normal state of dilatation ; but the animal breaking loose tore off the dressings and irremediably compromised the success of the operation. [Tudor* describes persistent shying in a mare caused by displacement of an enlarged corpus nigrum, which he removed successfully. Nine months after, when the case was reported, she had not shown the least disposition to return to her former bad habit. Their presence, however, does not often cause any palpable trouble].

Diagnosis is as a rule not difficult; care must be taken, however, not to mistake synechiæ for enlarged corpora nigra, and *vice versâ*.

Albinism. Absence or rarefaction of the pigment of the uveal tract gives the eye a peculiar appearance. Partial or total albinism of the iris in the horse is well known (wall-eye). It is also met with in the cat and in dogs, especially in Great Danes, in the Siamese cat and in the white Persian cat with blue eyes, and in the Arkwright or merle collie ; in the goat, also in the pig. Albinism of the choroid is not rare in the horse, in the tapetum nigrum which assumes a brick red tint easily illuminated with the ophthalmoscope. It sometimes co-exists with coloboma of the tapetum. Total albinism is frequent in [the horse, especially in the State Hanoverian cream horses, the skewbald, the piebald, the spotted, and in those having a large pigmentless blaze extending to the eyes], the rabbit, [in guinea-pigs, tame rats and mice and the ferret. In inbred or sibbred, and in the cinnamon-bred canary, the eyes are often pigmentless. In the cinnamon canary, at the earlier part of its life, pigment is absent, but later on a chocolate pigment appears]. An eye showing albinism is more easily irritated by light than a normal eye. [In man it is usually accom-

* *Journal of Comp. Path. and Ther.*, Vol. I, 1888, p. 54 *et seq.*

panied by nystagmus; and in dogs and cats, often by deafness].*

[**Heterophthalmos and Heterochromia.** These terms are used to designate a difference in the colour of one eye to the other; also when the iris is partly of one colour and partly of another].

Operations on the Iris. *Iridectomy.* From a therapeutic point of view this operation has several objects: to combat the inflammatory condition in irido-cyclitis; the increased

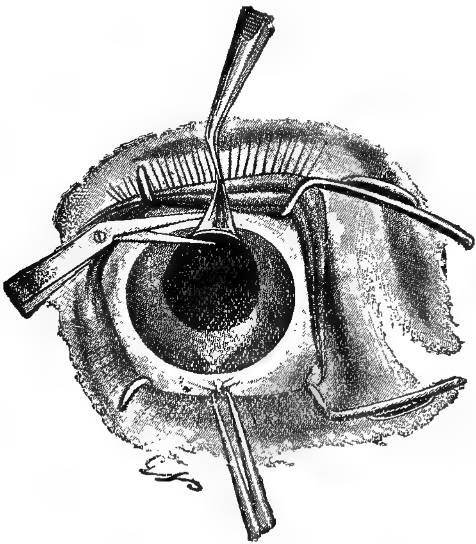


Fig. 103. Iridectomy (Cadiot and Almy).

tension in glaucoma; the creation of an artificial pupil when the natural opening does not play its part, as in central opacities of the cornea and in occlusion of the pupil; also to allow other operations to be performed, such as extraction of cataracts.

* For a fuller account of this condition see Part II of a Monograph on Albinism (including the albinotic eye in Animals), by Karl Pearson, F.R.S., E. Nettleship, F.R.S., M.R.C.V.S., F.R.C.S., and C. H. Usher, M.B., 1913.

Site of Operation. When the object is to improve the sight the position is determined by the situation of the transparent part of the cornea. In other cases the most convenient position for the surgeon is chosen.

In man the size of the orbital opening compared with the dimensions of the eye, allows the operation to be performed throughout the whole extent of the sclero-corneal limbus; but the upper part is most usually selected.

It is the same in the dog. In the horse, and for reasons which are elsewhere explained (*See* Treatment of Cataract), the best situation for operation is the limbus corresponding to the temporal canthus of the eyelids.

Instruments. Eye speculum, fixation forceps; von Graefe's knife if the incision is to be a large one, a triangular keratome the base of which should measure about 12 mm., and the altitude about 15 for preference if the operation is to be confined to iridectomy; iridectomy forceps, small curved scissors or de Wecker's iris scissors.

The animal may be anæsthetised, or the eye may be simply but effectually treated with cocaine. General anæsthesia is preferable to local anæsthesia.

Having irrigated the eye and the conjunctival culs-de-sac with boiled solution of boracic acid or of sublimate 1 : 4000, place the eye speculum in position.

Fix the eye by means of fixation forceps by seizing the conjunctiva exactly opposite the place at which the section of the cornea is to be made, pull down the eye in such a way that this part is easily visible.

Puncture the cornea, counter-puncture and cut upwards, so making a semi-circular incision of the cornea if von Graefe's knife is being used; in the contrary case puncture the cornea with the keratome forced in as far as the shoulder (Fig. 71), in order to make the opening of sufficient size to allow of the fifth stage in the operation.

Fig. 102.

von Graefe's knife.

Give the fixation forceps to an assistant with the caution that he is not to exert any pressure on the eyeball which would tend to cause a hernia of the vitreous humour. Should this appear between the lips of the wound and protrude, excise it by means of the curved scissors.

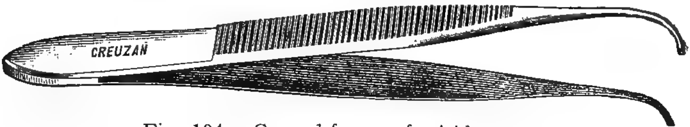


Fig. 104. Curved forceps for iridectomy.

Seize a portion of the iris with the iridectomy forceps, draw it outside the eye and cut it on a level with the corneal incision; then see that no part of the iris is left between the lips of the wound in the cornea to interfere with regular cicatrisation. Remove the fixation forceps and the eye speculum.

In the horse and dog this operation almost always causes a little hæmorrhage into the anterior chamber, which is some time in becoming resorbed. [This may, however, be prevented by the use of adrenaline instilled or

Fig. 105. Small curved scissors for iridectomy.

injected into the eye some time before commencing the operation]. A dressing to close the eye must be applied either in the form of a hood or Brusasco's apparatus, or by means of four interrupted sutures through the eyelids and closure of the wound with collodion. The internal angle of the eye must be cleansed daily, and about the sixth day the sutures must be removed and the eye left to itself. Horses should be placed on the pillar reins, dogs should have their paws tied together.

CHAPTER VII.

THE RETINA AND OPTIC NERVE.

Anatomy and Physiology.

The Retina. This membrane which is essentially of nervous structure is very sensitive to light and covers the inner face of the choroid from the entry of the optic nerve to the ora serrata. Viewed in the living animal by means of an ophthalmoscope, it is absolutely transparent because the nervous fibres are deprived of their myeline sheath. It is the same in a freshly enucleated eye, but when seen in mass or looked at obliquely it is slightly whitish. In eyes having an opaque cornea, or with a cataractous lens, it shows a more or less pinkish colour; this tint which has frequently been seen to disappear on exposure to light is due to the presence of erythropsine or "*retinal red*" discovered by Boll in the rods, a substance which is developed in darkness and which is decomposed by light forming a persistent image on the retina lasting for some seconds.

In the Leporidæ, and exceptionally in other species, the myeline persists in certain regions near the papilla which are then absolutely white and opaque (opaque nerve fibres; Fr fibres à myeline or fibres à double contour). Post mortem alterations as well as pathological lesions of the retina are alike betrayed by a loss of transparence.

Maintained in contact with the choroid by the pressure of the vitreous humour, the retina follows this humour when it is diminished in volume from any cause; it becomes detached from the choroid, the condition being known as *detachment of the retina.*

It is a thin membrane, especially in the horse, and presents two regions for consideration; the optic papilla and the

macula lutea, area centralis retinæ, [or sensitive area] according to the species under consideration.

The *optic papilla* or disc, also called the punctum cæcum or blind spot, is the point from which the fibres of the optic nerve spread out.

It is situated more or less near the posterior pole of the eye, but is always found in the inferior hemisphere and towards the temporal side, except in man and monkeys, in which it is in the nasal half. It varies in shape according to the species; elliptical with its major axis horizontal in the horse; triangular with rounded angles or sometimes trifoliate in the dog; in the ox and sheep it forms a badly defined

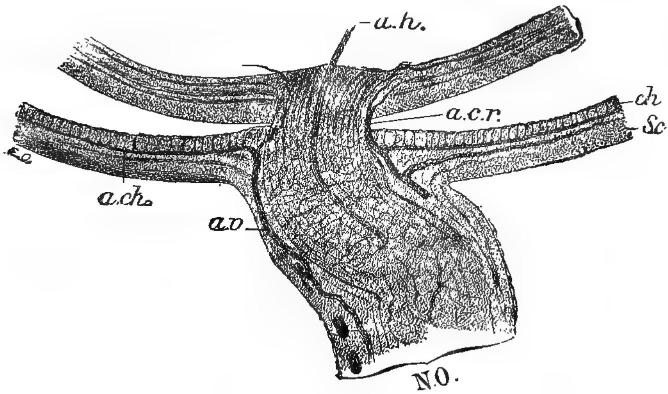


Fig. 106. Transverse section of the region of the papilla of a newly born cat. (O. Schultze, Encycl. franç. d'ophtalm).

ah, Hyaloid artery, a prolongation of the central artery of the retina, giving no branch to the retina *r*. *acr*, Cilio-retinal artery. *ach*, Choroidal artery. *av*, Ciliary artery. *ch*, Choroid. *sc*, Sclerotic. *No*, Optic nerve.

circle, whilst in man, the cat, and goat it is quite circular; its colour also varies: white in the ox and sheep; more or less pink or red in the other animals as in man. Far from being a projection into the interior of the eye, as its name would indicate, it is usually [physiologically] hollowed out

like a cup. In the horse, in which this is very clear, the excavation is about 1 mm. deep.

The macula lutea or yellow spot, so called because of its colour in man when seen post mortem, or the fovea centralis retinæ on account of its being a small depression and its position at the posterior pole of the eye, is the most sensitive part of the retina on which the animal focuses the image of an object which it wishes to see clearly. It has a peculiar structure of its own.

Simian apes, without exception, are among mammals, the only animals having a macula like that of man. Moreover man and these apes only have the power of convergence.

Birds have two (H. Müller), one situated at the centre of the posterior segment of the retina, the other more or less near to the ora serrata on the temporal side. [They are also present in some of the Lacertilia].

In the other animals, the fovea is replaced by a somewhat special zone (from an anatomical point of view), to which the name *area centralis*, or sensitive area is given ; but it cannot be distinguished by the naked eye post mortem, nor with the ophthalmoscope in the living animal. In the retina of the *horse* and *ox* it is disposed in the form of a broad transverse band bordering inferiorly the tapetum lucidum (Chiewitz), or immediately above the disc and peripheral zone. In the *dog* and *cat*, the area centralis is rounded in form or may be slightly elliptical in the horizontal direction and is situated in the tapetum lucidum below the horizontal temporal vessels, or immediately posterior to the optic disc. The central sensitive area in the dog and cat, as well in most of the other Carnivora, is distinguished by a distinct difference of colour, generally a glistening golden yellow, and by a noticeable want of vessels over a well marked zone lying above the papilla and on the posterior or outer side of the axis of vision.

Circulation of the Retina. Central artery of the Retina, and the cilio-retinal vessels. As a rule the vessels of the retina come from the arteria centralis retinæ. But, contrary to what is the case in *man* [in whom it would be an anomaly],

in many animals they have also a ciliary origin (cilio-retinal vessels). In the carnivora—*dog*, *cat*, and *fox*—many of the very numerous short posterior ciliary arteries give a branch to the papilla and to the retina before bending round into the choroid (fig. 106). In *ruminants*, the *pig*, and in *rodents* these cilio-retinal vessels are much less developed (Hoffmann).

According to Langenbacher, one part of the vessels of the retina of the horse are also of ciliary origin.

Emerging near the periphery of the papilla the cilio-retinal vessels can only be recognised with the ophthalmoscope in retinæ, having the papillary vessels normally central.

According to the species the vessels of the retina emerge from the centre or from the periphery of the papilla and are long or short; they may even be completely wanting. On this account Leber describes, from a comparative point of view, several kinds of retinæ.

Retinæ having a complete vascular system. The vessels extend from the papilla to the ora serrata forming three or four principal branches. (*a*) They emerge from the centre of the papilla as in man, dog, pig and ruminants. (*b*) They emerge from the periphery of the papilla as in felines —the cat, etc.

Retinæ with a partial vascular system. In the Leporidæ the parts of the retina furnished with opaque nerve fibres, that is temporal and nasal parts only, are vascular.

Retinæ with their circulation developed only at the circumference of the papilla or having no circulation. (*a*) The circulation is limited to the circumference of the papilla: horse and elephant. In the horse the length of the vessels is about one diameter of the papilla at the sides and about half a diameter above and below. (*b*) There is no circulation in the rhinoceros.

The retina which has its own circulation in most species, in others (as in the horse), is obliged to borrow from the subjacent vascular membrane—the choroid. On this account it is not astonishing that in the horse it so often participates in affections of the uvea.

Structure. In the following account the old diagrammatic description of the retina will be adhered to as being sufficient and convenient for the purposes of pathological anatomy and clinical work, and in matters regarding histology, Golgi's method, and the works of Ramon y Cajal, and the masterly articles of Rochon-Duvigneaud and Kalt are quoted (Vols. I. and II. *Encyclop. franç. d'ophtalm.*).

The retina is composed of a nervous tissue and a tissue which acts a framework. The nervous tissue is formed of several layers which are, going from the internal to the external face (See fig. 107):—(1) A basal membrane, or the membrana limitans interna; (2) the layer of nerve fibres issuing from the optic nerve; these are thicker at the centre of the retina than at the periphery; each of the fibres is destined for a cone or a collection of cones; (3) the layer of ganglion cells; (4) the internal reticular plexus formed by the terminations of the cells of the neighbouring layers; (5) the internal molecular layer; (6) the external reticular plexus; (7) the external molecular layer; (8) the membrana limitans externa; (9) the rods and cones; (10) the pigmentary layer.

The framework tissue is formed of large cells (fibres of Müller) placed one beside the other, like palings, and having their broader ends supported on the "limitans interna."

In man the capillaries do not penetrate deeper than the external reticular plexus; in the ox and sheep they have been recognised as far as the limitans externa.

The region of the area centralis is histologically characterised by a great thickness of the retina, due to a multiplication of the ganglion cells and the molecular elements and to the increase in the dimensions of the receptive elements—the rods and cones.

In the vicinity of the fovea centralis, on the contrary, the retina is thinner and reduced to the layer of rods and cones. It is an improvement of the area, for in the human fœtus according to Chiewitz, the area exists primarily, the fovea not being formed until the commencement of the sixth month.

According to the species the retinæ differ histologically, but only as regards the relative thickness of the layers and the number and dimensions of the rods and cones. The rods predominate and are increased in length in animals which see best at night (Schultz), whilst in those having diurnal vision the cones are more numerous.

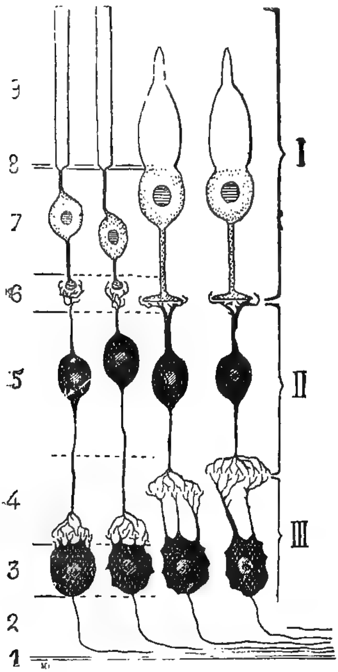


Fig. 107. Diagram of the retina (Mathias Duval). 1, Membrana limitans interna. 2, Layer of nerve fibres. 3, Ganglion cells. 4, Internal reticular plexus. 5, Internal nuclear layer. 6, External reticular plexus. 7, External nuclear layer. 8, Membrana limitans externa. 9, Rods and cones.

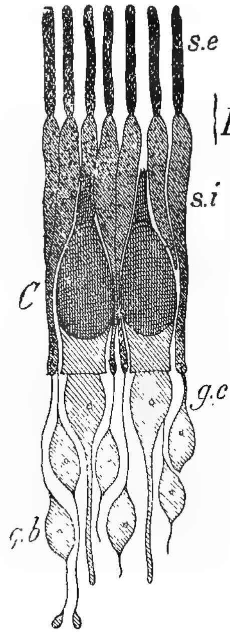


Fig. 108. Visual cells—the rods and cones of the retina of a pig. (Greef. Encyclop. franç. d'ophtalm.). *B*, Layer of rods. *C*, Layer of cones.

According to Zürn, in the horse, in ruminants and in the pig, the perceptive and conductive elements are more developed in the temporal than in central and nasal portions of the retina, a disposition which has doubtless some connection with binocular vision.

At the edge of the ora serrata the transition between the retina proper, and the ciliary portion takes place gradually in the horse and ox, in a more abrupt manner in the dog, but in no animal is the limitation so clear as it is in man.

Optic Nerve. This is a cord formed of nerve fibres which go to form the retina, and it extends from the posterior pole of the eye to the cranial cavity, passing through the optic foramen.

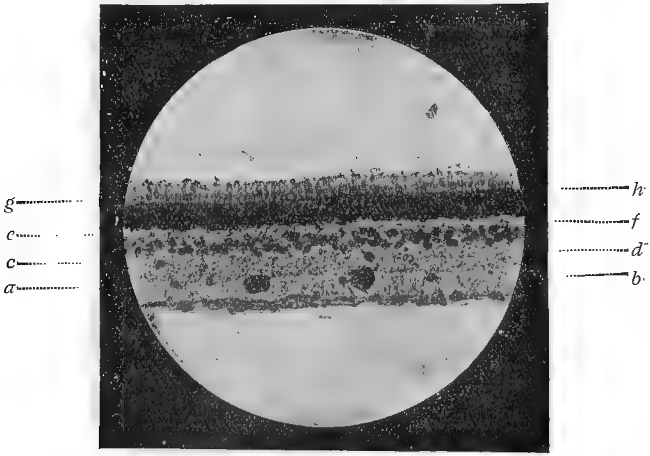


Fig. 109. Section of the retina of the horse.

a, Layer of optic fibres. *b*, Ganglion cells. *c*, Internal reticular plexus. *d*, Internal nuclear layer. *e*, External recticular plexus. *f*, External nuclear layer (on three rows). *g*, External limitative membrane. *h*, Rods and cones.

All the preceding layers can be recognised. On the line *ab* two ganglion cells can be seen. The external nuclear layer is better marked than the internal.

Three portions may be distinguished in its tract: intra-ocular, orbital, and intracranial.

Intraocular portion. Comprised in the thickness of the eyeball, this portion is narrowed or constricted in comparison with the extraocular portion, the nerve fibres no longer having any myeline sheath. Before going to form the retina the optic nerve passes through the *lamina cribrosa*, which is poorly developed in quadrupeds, such as the dog, sheep, and horse, and is only represented by the choroidal portion (Hoffmann). The constriction of the nerve in its ocular sheath explains the symptoms of papillary stasis, which will be described later.

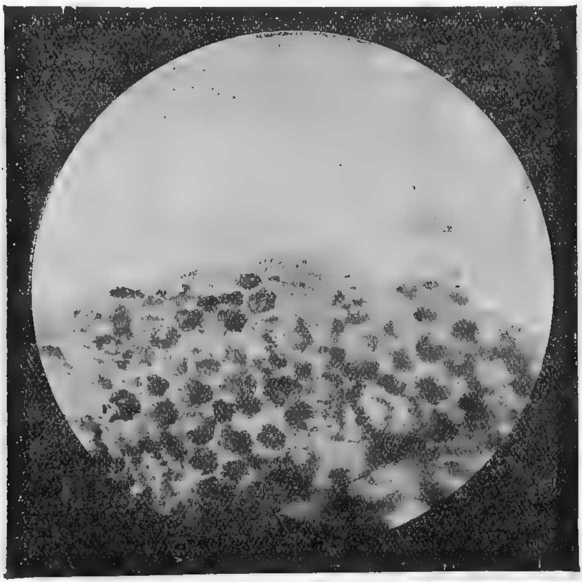


Fig. 110. Pigmentary cells of the retina of the horse.

Orbital portion. This is a greyish-white cylindrical cord, hard to the touch, measuring with its sheath about 5.5 mm. in diameter in the horse, 4.5–5.5 mm. in the ox, 3 mm. in sheep, 2.8 mm. in pigs, 1.1 mm. in cats, and 1–2 mm. in the dog

(Koschel). It extends from the orbital hiatus to the eyeball, which it enters more or less obliquely. Inside the orbital sheath the optic nerve forms undulations which allow the eyeball to move without the nerve being stretched.

Its structure is that of an ordinary nerve surrounded by three membranes or sheaths which are prolongations of the cranial meninges. It is therefore possible to distinguish a very thin pia mater directly covering the nerve, serving as a neurilemma and sending into the interior folds which partition off the nervous bundles; a thicker dura mater forming the external envelope; and between the two the arachnoid sheath with its two layers, especially well seen in the ox and sheep. This ends in a cul-de-sac in the ocular portion, whilst the two others are lost in the sclerotic.

Intracranial portion of the optic nerve and the continuation of the optic fibres as far as the cerebrum: The optic nerve is continued from the orbital hiatus to the chiasma in the form of a cylindrical cord. Beyond the chiasma it forms a *flattened band called the optic tract* which turns round the cerebral peduncles to go to the external geniculate bodies, beyond which it is impossible to follow the course of the fibres with the naked eye. Further information on this point has been furnished from pathological and experimental researches. This will be considered later.

There is some question as to whether these optic fibres cross completely at the optic chiasma (decussation). In other words, do the fibres of each nerve partly pass into the opposite tract (crossed fibres) and partly into the tract of the same side (direct fibres), or, as it is called, do the fibres undergo semi-decussation?

The anatomical researches of Biesiadecki, Mendelstamm, and more especially of Michel, suffice to show that in the lower vertebrates, fishes, amphibia, birds, the two optic nerves cross completely, that there is decussation, so that the fibres of the right optic nerve, for example, go to the left lobe of the cerebrum and *vice versâ*. The optic nerves here follow the general law that sensations coming from one side of the

body are perceived by the opposite cerebral lobe. In fishes the nerves simply pass one above the other, only being united by the neurilemma. In amphibia, reptiles and birds the nerves divide into transverse bundles surrounded by neurilemma which cross successively with those of the opposite side.

In mammals the entry of the two nerves is more intimate, the bundles are no longer surrounded by a connective tissue envelope allowing the course to be followed, and though methods of staining have made it possible to obtain certain results it is chiefly to the method of Wallerian degeneration that the present knowledge of the course of the fibres in the chiasma is due.

In the rabbit the intercrossing is almost complete, but some disseminate direct fibres remain not forming a distinct bundle.

In the calf, sheep, and pig, Kölliker has recognised direct fibres, but they are few in number. Dexler has made the same observation in the horse. In the cat Cajal saw the degenerated fibres continued $\frac{2}{3}$ in the opposite tract and $\frac{1}{3}$ in the corresponding tract. The direct fibres, without forming distinct bundles, are nevertheless abundant on the external edge of the tract. The arrangement is almost the same in the dog (Gudden, Darschevitzch, Tornatola).

In monkeys, as in man, the direct and crossed fibres are almost equal in number (Bernheimer).

Briefly stated, this means that crossing is complete in animals in which the eyes are quite laterally placed, and in which the visual fields are distinct, *i.e.*, in those which have monocular vision. In proportion as the degree of development becomes higher the eyes diverge less and less, the visual fields cover one another partially in front, and then semi-decussation begins to appear as an anatomical proof of binocular vision (*See* diagrams 112 and 113). The owl, which has the eyes placed in an anterior plane and the optic nerves of which cross completely (Gudden), seems to be the only exception to this rule.

On leaving the chiasma the nerve fibres forming the optic

tracts go to the external geniculate bodies, to the anterior corpora quadrigemina, and to the posterior eminence of the optic thalamus, regions which the experiments of Gudden and von Monakow on the rabbit, cat and dog, have shown to be solely concerned with the visual function. Then from these inferior centres they go to the posterior part of the occipital lobes (cortical visual centre). Post mortem examinations of horses made by Cadoré and Rousseau have shown that lesions situated on a level with the occipital lobes can cause blindness.

Pupillary Fibres. According to experiments and examinations of degenerations made by Gudden on rabbits, there exists in the retina and in the optic nerve, independently of the visual fibres proper, other nerve fibres which leave the bundle of optic fibres after the external geniculate body to go to the motor nuclei of the iris, situated under the aqueduct of Sylvius and in the floor of the fourth ventricle. These fibres, sensitive to light, represent the centripetal portion of the reflex pupillary arc, the centrifugal portion of which is formed by the sphincter motor fibres of the common oculo-motor.

The independence of this arc and its disposition explains the fact, observed pathologically in man and experimentally in animals by Bach and Meyer (*See* p. 92), that cortical blindness is not accompanied by any alteration in the reaction of the pupil.

The Visual Function. The retina is the sensitive plate of the eye; without it there could be no perception of objects, however perfect the rest of the organ might be. But in this membrane it is the rods and cones which play the most important part, as they receive the luminous rays to transform them into nervous stimuli; now, if the position of these rods and cones in the retina be considered, it can be seen that this membrane must be absolutely transparent for the rays of light to reach them.

Acuteness of vision. Central and excentric vision. By acuteness of vision is meant the power which the eye possesses of distinguishing objects from one another, and of separating

two neighbouring points. This power is increased as the two objects become smaller or nearer together. It depends on the sensitiveness of the retina and on the transparency of the media, but other things being equal it varies with the region of the retina. It is most perfect round the fovea centralis (central vision) and for this reason a man always directs his eye so that images are formed on this region. *By means of the fovea we can appreciate the form of an object.*

In proportion as the image is formed further away from this point the sensitiveness of the retina decreases considerably (*excentric vision*). In man for a digression of ten degrees from a fixed point the acuteness of vision falls to .07 below the normal; at 35 degrees the vision is reduced to the perception of the fingers; at 45 degrees objects are very vaguely seen (Kalt). By the excentric regions of the retina we have a collective or panoramic vision.

Simian apes, [lacertilian reptiles], and birds are the only animals which, possessing a fovea and a very powerful accommodative apparatus, can be considered as having a central vision comparable to that of man. Felines approach very closely to this. Central vision in animals only possessing an area must be very imperfect; these animals are especially guided by the displacements of objects: "It is common knowledge that a dog sees badly, that he cannot recognise his master at some paces distant when the latter avoids making any movements and keeps down wind of the dog" (Kalt). It must be noted, however, that a dog sees quite well a stick, for example, which is held for him to jump over, and that a horse perfectly perceives a fence at ten yards distance, or at any rate well enough to "clear the fence." The size of the images on the retina in this animal (4 times in area that of man), and the proportional illumination which the possession of a pupil four times the size of that in man must allow, should to some extent compensate for the less sensibility of the area compared with that of the macula.

Central vision is useful to the individual within fairly wide limits according to the uses to which he puts it. A seamstress has need of a greater acuteness of vision than a

labourer; a swallow which catches an insect while on the wing, and a feline which bounds on its prey have need of a greater acuteness of vision than a ruminant. Its utility is therefore to some extent relative.

Excentric, or panoramic vision is, however, absolutely necessary to the conditions of life. An idea of its importance can be gained by looking through a tube which suppresses peripheral vision. Walking becoming, if not impossible, quite dangerous, for the individual is at the mercy

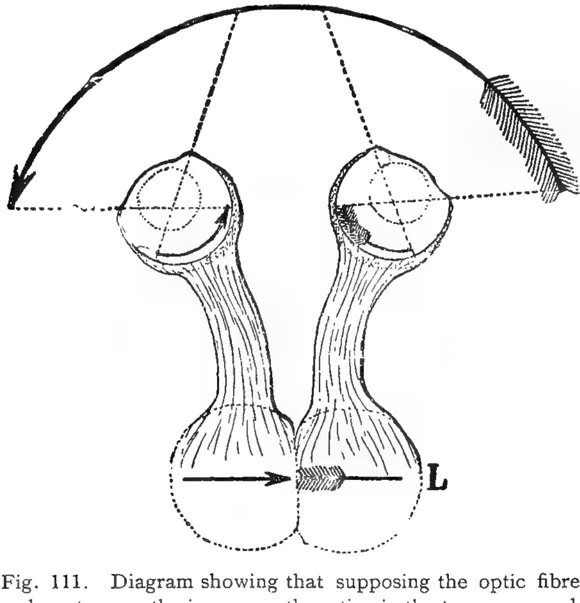


Fig. 111. Diagram showing that supposing the optic fibres do not cross, the images on the retina in the two eyes would have an abnormal projection in the cerebrum (Cajal, Encycl. franç. d'ophtalm.).

of irregularities of the ground and of any obstructions which may be met with laterally, which he cannot see or avoid.

The visual field. Panoramic and semipanoramic vision. The whole surface of the retina being sensitive, although in different degrees, each eye taken separately gives a total

image of a portion of the horizon, which is called the monocular field of vision. When the eyes are placed quite laterally the monocular visual fields are distinct, or may be placed next to one another in the median line (panoramic vision, Cajal) (See fig. 112). The total visual field is then equal to the sum of the visual fields of the two eyes. As the eyes become less divergent, the monocular visual fields

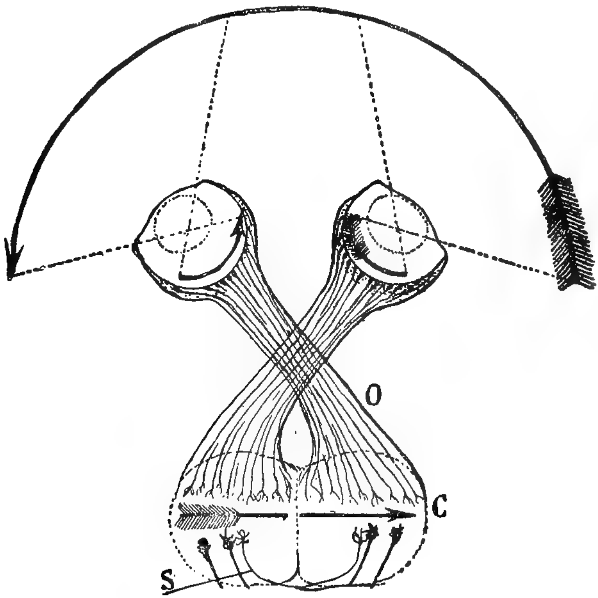


Fig. 112. Diagram showing the action of the total inter-crossing (decussation) of the optic nerves in an animal with panoramic vision (fishes, reptiles, birds, lower mammals) (Cajal). The cerebral projection of the images on the retina forms a continuous whole (Encycl. franç. d'ophtal.).

overlap more and more on the middle line : semi-panoramic vision (fig. 113). In this case the total visual field is not equal to the sum of the monocular visual fields, one part which is called the visual field of binocular vision being common to both eyes.

Cajal's diagrams explain in a very suggestive manner how the fusion of the images obtained by each eye takes place in the brain, and at the same time they show the physiological reason for the decussation of the optic nerves (fig. 111).

The extent of the field of vision. The visual field of monocular vision in man is about 100°. According to Grossmann and Mayerhausen its extent increases with that of the arc of the corneal circle. In man this arc is the smallest and measures 80°, in monkeys 81°, in felines 100° and in rodents 112°. However, according to Kalt, from direct examination of enucleated eyes as to the images which are formed on the fundüs oculi in rabbits and in man, the portion of the field included, although apparently so different, is practically the same. Increase in the size of the corneal arc would only serve to increase the illumination of the peripheral image.

The total field of vision, that is to say, that formed by the sum of the monocular fields of vision, increases with the divergence of the eyes. The more distant the object in man, in which it is about 200°, the more does the field of vision extend backwards. In the rabbit in which the fields of vision touch in front and may even overlap, they touch behind in the middle line, the eye being in a state of rest. The action of the external straight muscles even allows, in this animal, binocular fixation behind (Grossmann and Mayerhausen). These authors have determined the total field of vision in the elephant—313° as being the same (approximately) as that of the horse.

The binocular field of vision is that which is common to the two monocular fields and depends upon the divergence of the eyes and the angle "Y," this angle being formed between the axis of the eyeball and the visual axis.

The further the fields of vision extend backwards the less tendency they have to cover one another in front, but on the contrary, the more the angle "Y" increases the more does binocular vision become possible in front. Whilst in man the visual axis pierces the cornea 5° inside its centre, through which the ocular axis passes in animals (angle "Y") (in

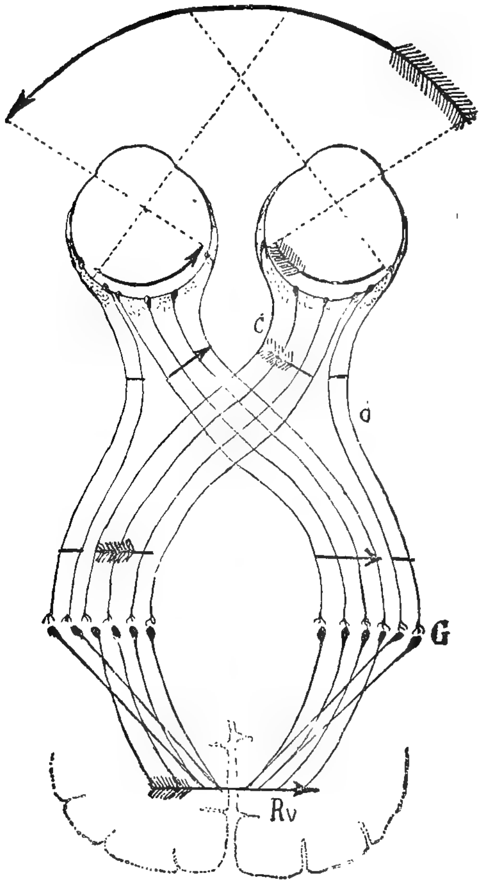


Fig. 113. Diagram showing the action of the partial intercrossing (semidecussation) of the optic nerves in a mammal having semipanoramic vision (Cajal).

c, Crossed optic fibres. *d*, Direct optic fibres. *G*, Primary optic centres. *Rv*, Cortical visual centre with the mental projection of the object (Encycl. franç. d'ophtalm.).

which it has been found possible to fix it), Grossmann and Mayerhausen have found that this angle increases from monkeys downwards, and reaches 60° and more in the large domesticated animals.

The binocular field which is 120° in man is the same in the lion, 67° in the elephant, and about 20° in the rabbit.

Binocular vision. The existence of the semidecussation of the optic nerves and of a field of vision common to both eyes in the higher animals proves the reality of binocular vision.

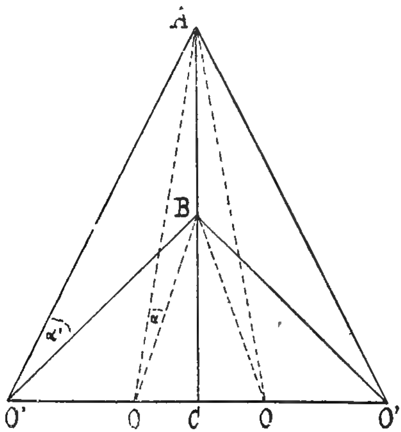


Fig. 114.

But its field is less extensive than in man, convergence being only possible in certain animals, as the horse, beyond 1–1.5 metres.

It is largely on this account that without displacement of our bodies, we can perceive the third dimension of solid bodies (*stereoscopic vision*), since in consequence of the space between our eyes, objects are seen at two angles, and so two different faces are seen.

Binocular vision therefore contributes greatly, with the aid of the muscular sense, in allowing the *appreciation of distances* in space.

To see two distinct points in space successively man converges from the more distant point to the nearer at the same time as he accommodates; he thus obtains, from the convergence of the muscles and from the accommodation, information which, with the aid of experience, allows him to appreciate the distance separating the two points considered, and the muscular sense also allows him to estimate the weight of the objects. Taking into consideration the fact that certain animals, such as the chamois and horse, show a rapid formation of judgment in jumping and in appreciating the size of the objects which they are to clear, Berlin has given his opinion that these animals possessing a less powerful vision than man, and having a rudimentary accommodation, owe this power of estimating distances to the distance between their eyes (*See* Comparative table, p. 7). Referring to fig. 114 it can be seen that to appreciate the distance between A and B the visual axes of the eyes O′ O′ describe the angle α' proportional to C O′ while the eyes O O only describe the angle α proportional to C O.

In the horse and man, for example, C O′ and C O, being as three is to one, the muscular sensations received by the eye O′ O′ will be three times as strong as those received by O O, and from these the horse will gain information which a man could not have in the same degree. Helmholtz, by the telestereoscope (now used as a toy), has realised the condition of an increased basal line for the eyes, and has thus shown that the sensation of relief or depth becomes clearer.

To this same cause, the widening of the interocular base, the elephant owes his highly developed perception of equilibrium.

Experiments and observations on horses and dogs by Berlin have shown that animals with one eye, or those artificially deprived of binocular vision, are less clever in jumping. [General Smith, however, has not observed in any of the many horses he has encountered with one eye failure to do what is required of them. Probably binocular vision is a complicated reasoning process acquired by experience; all

animals no doubt have this faculty but do not absolutely always call it into play. In man the closure of one eye makes an exact estimation of distances in space no longer possible. In the case of the loss of sight in one eye the sound eye can be so educated as to compensate for the loss of the other].

In birds, which have no binocular vision, as can be seen by the lateral displacements of the head at each step in order to "place objects which interest them in the direct line of vision" (Kalt), the contractions of the accommodative muscular apparatus which is highly perfected, serve in the appreciation of distances, a faculty which is possessed in a high degree by the feathered world.

Diseases of the Retina.

Retinitis. Inflammation of the retina frequently observed in the horse as a sequel to irido-choroiditis is much more rare as a primary affection. It has, however, been recognised as such in the domesticated animals.

Symptoms. These are exclusively ophthalmoscopic. The effusion, in penetrating the retina, produces a disturbance in the transparence of the membrane which always modifies the image of the fundus oculi to some considerable extent.

The exudate or infiltrate is whitish, or more often yellowish. If it is limited to the external layers of the retina it only masks the tapetum lucidum, the brilliant vivid colours of which become dull and the ocellated points seem to be immersed in a turbid fluid. If it invades the internal layers the vessels of the retina become covered in places or throughout their whole extent. The vessels are more sinuous than normally; they are interrupted, their margins are indistinct, and some are constricted while others are dilated.

Usually generalised, the disturbance of the retina may sometimes be so intense that, as Nicolas has observed in a cat, the depth of the eye may be only of a dull slaty grey colour, a condition which is so confusing that it is difficult to make out the landmarks. More rare are those cases in which the disturbance is localised in the form of white, grey, or yellow patches.

The papilla is always implicated in the inflammation.

To these defects of clearness in the fundus oculi are added retinal hæmorrhage, rare in the horse if the frequency of the occurrence of choriodo-retinitis be considered, but it has been recognised by Peters and Schindelka at the circumference of the papilla; it is more frequent in other animals in which the circulation of the retina is more developed.

Lastly retinitis is almost always accompanied by *pigmentary disintegration*, giving the fundus oculi a tiger-striped appearance.

Under the name of *pigmentary retinitis* van Bierwliet and van Rooy* have described in the horse a form which they have compared to pigmentary retinitis in man though Nicolas considers that they were wrong, and that their description in reality was one of a case of peripapillary choroiditis.

It is certain that retinitis exists and that the retina may be penetrated by pigment, for it has been seen by ophthalmoscopic examination, but lesions of choroiditis also exist, and besides this the pigmentary retinitis of van Bierwliet and van Rooy and that which is seen in man are quite different. Pigmentary retinitis in man is mostly congenital and is probably of syphilitic origin, occurring excentrically and in both eyes: in the horse the affection described by the Dutch authors has evidently some connection with uveitis, which is proved by the almost constant co-existence of traces of anterior uveitis; furthermore it is generally unilateral and always peripapillary. Instead of becoming pigmented, as in man, the fundus oculi loses its pigment in the horse, and is strewn with patches very much resembling those of disseminate choroiditis, in which, as Nicolas has shown, the circumscribed areas may become united and form peripapillary choroiditis. Lastly, though in man the pigment has a tendency to become grouped in the neighbourhood of the vessels which it covers, in the horse it is distributed quite regularly and does not interrupt the course of the vessels. Van Bierwliet

* Annales de Méd. Vét, 1862. Archiv für Ophthalmologie, 1864.

and van Rooy have even recorded the existence of hemeralopia (night-blindness) in the horse. But if this symptom in man is explained by the excentric position of the retinal lesions, how can it be explained in the horse in which the lesions are central? It must be mentioned that the affection, usually a serious one in man, does not seem to affect the sight of horses to any great extent. [As far as is known, the only case resembling retinitis pigmentosa, also termed pigmentary degeneration of the retina, recorded as occurring in the domesticated animals is that of Magnusson, of Malmö,* Sweden. This author witnessed it in a valuable breed of Gordon Setters. The hereditary taint seemed to be traced to a certain unaffected imported dog called "Ranger." Being a valuable dog, some very close in-breeding was carried out with him, so that degrees of consanguinity never approached in human relationships were attained. The first animal to be affected was the product of a pairing of a full brother and sister, the puppies of "Ranger," so that "Ranger" was the grandfather on both sides. As all the other members of this litter were destroyed, it is impossible to say whether any of them would also be affected. In the next litter "Ranger" was also grandfather on both sides, but the parents were only half-siblings; in this litter three dogs were affected, and one dog and two bitches were unaffected. The third litter was by "Ranger," who was at once the father and the great-grandfather; the result in this case was two affected (a dog and a bitch) and three unaffected (two dogs and a bitch).

When about six months' old the animal manifests evidence of visual disturbance in the form of night-blindness, which is practically complete in about a year. In one case all sight was lost in four years. Thread-like opacities may be present in the vitreous, the disc is grey, and the vessels are very small. Pigment is present in greater amount than normal, and encroaches on the tapetum lucidum; it has the form of a coarse

*H. Magnusson, Ueber Retinitis pigmentosa und Konsanguinität beim Hunde. *Archiv für vergleichende Ophthalmologie*, Band II., Heft ii., S. 147, 1911. Abstract by George Coats, *The Ophthalmoscope*, Vol. ix., 1911, p. 713.

network with processes and isolated patches. Bone-corpuscle forms, and the equatorial zones are not typically present.

Pathologically, there is profound degeneration of the retina, affecting especially its outer layers, but in places amounting to complete atrophy of the whole membrane. The choroid is atrophic and the choriocapillaris thin and its vessels are scanty, but the larger choroidal vessels are normal and the stroma pigment is unaltered. The pigment epithelium shows irregularity and proliferation, but the amount of pigmentation of the retina itself is slight as compared with the extensive atrophy, and is present chiefly where the retinal disease is very advanced. Nowhere was there any evidence of inflammation. Gray has endeavoured to trace back the pedigree of the dog "Ranger," but as there are several dogs of this breed having the same name recorded in the Kennel Club Stud Book he has, up to the time of writing, been unable to unravel this dog's lineage. In the retinæ of certain nocturnal animals exposed to daylight for a long while, a deposition of pigment advancing from the ora serrata towards the disc is seen, giving rise to an ophthalmoscopic appearance resembling retinitis pigmentosa in man. It gradually produces blindness. In man its hereditary occurrence shows Mendelian characters. The prevalent form of night-blindness in a particular family for several generations may show the absence of pigmentary or other degenerations of the retina, as in the case of the descendants of Jean Nougaret who, for 250 years, have suffered from congenital night-blindness, in contradistinction to the much commoner, progressive retinitis pigmentosa. In this family consanguineous marriages were the rule rather than the exception. Defective perception of vision gets neither worse nor better with age. The affected individuals claim to see farther and better in a good light than their normal-sighted neighbours *].

* E. Nettleship. A History of Congenital Stationary Night-blindness in nine Consecutive Generations. Transactions of the Ophthalmological Society, Vol. xxvii.

Pathological anatomy. The lesions of retinitis are of several varieties. Rivolta, who has studied retinitis in horses affected with periodic ophthalmia and in bovines suffering from "internal ophthalmia," has divided the forms of retinitis according to the nature of the lesions, and considers the disease as simple or congestive, hæmorrhagic or apoplectic, serous or sero-fibrinous, hyperplastic, metaplastic and pigmentary retinitis. This classification adopted by Vachetta, besides being purely fictitious is likely to give wrong ideas from the point of view of comparative ophthalmology. For example, though there may be an infiltration of pigment into the retina, it does not follow that it is due to a pigmentary retinitis like that of man.

The best known lesions are those which are consequent on inflammation of the uveal tract.

They consist of serous, sero-fibrinous, cellular, superficially situated exudates, forming adhesions with the choroid or to a greater or less extent penetrating and disorganising the retina. Eversbusch has found this membrane divided into two layers by an *exudate;* vascular alterations, congestions, degenerations of the vessel walls ending in hæmorrhages; atrophic alterations, particularly of the rods and cones, but also of the molecular layer and of the layer of nerve fibres; sclerosis from excessive production of connective tissue elements, or from hyperplasia of the stroma; more or less complete ossification of the membrane (Rivolta and Vachetta); pigmentation without any fixed distribution.

Etiology. The most diverse causes may give rise to retinitis. In the domesticated animals, and in the horse in particular, it chiefly follows the affections of the eye, choroiditis and optic neuritis. In every case of disease of the choroid the retina suffers; choroiditis *per se* does not exist; considered anatomically there is always choriodo-retinitis. If the symptoms of retinitis are not well marked in disseminate and peripapillary choroiditis, the destruction of pigment is a proof of the participation of the retina, while in diffuse choroiditis and irido-choroiditis the retina is always seriously affected. This

sympathy existing between the retina and the choroid arises from their contiguity and also because they depend on each other vitally.

By cutting either the long nasal ciliary artery or the group of short ciliary arteries in the rabbit it is possible to see with an ophthalmoscope a disturbance and folding of the retina developing in the corresponding nasal or peripapillary region; after a few days the alterations disappear, but white spots due to atrophy of the retina and patches of pigment are left; on examination of a section under the microscope, interstitial œdema of the retina and of the nerve elements can be seen; the rods, cones and molecular layers degenerate and disappear (Wagenmann). There exists a morbid sympathy between the optic nerve and the retina on account of their continuity; just as there can be no choroiditis without retinitis, there can be no optic neuritis without retinitis, and *vice versâ;* descending neuritis and papillary stasis are constantly accompanied by retinitis.

Infectious diseases, such as influenza and purpura hæmorrhagica, may cause retinitis in the horse (Peters, Schindelka, Möller), as also may general diseases—leucæmia (Fröhner).

Tubercular retinitis has been recognised by Cadiot, Gilbert and Roger, in an experimental rabbit, which also showed the lesions of specific arthritis; on one side there was a considerable dilatation of the vessels of the retina, with the formation of two small reddish tumours in connection with the vessels; on the other side the vessels were constricted. In the eye of an ox Nicolas observed the following alterations of the retina, which he also attributes to tuberculosis (Fig. 115): "A large greyish-yellow patch, distinctly granular in appearance, nourished by numerous newly-formed vessels, joined by a common branch to the vertical vessels of the retina." Two other white patches with smooth surfaces, one of which covers and partially hides one of the retinal vessels, reducing the double contour to a slight red thread. Hæmorrhages can be seen around the papilla, one of which is large, parallel to the superior vascular trunks and situated close to them;

it has its surface striated, and its ends have a flame-like appearance.

Post-mortem examination showed that hæmorrhages were entirely intraretinal, and that the patches were formed of exudates in different stages of evolution, situated in the retina but having formed some adhesions with the choroid. The nature of the granulations in the patch of exudate could not be discovered either microscopically or experimentally.

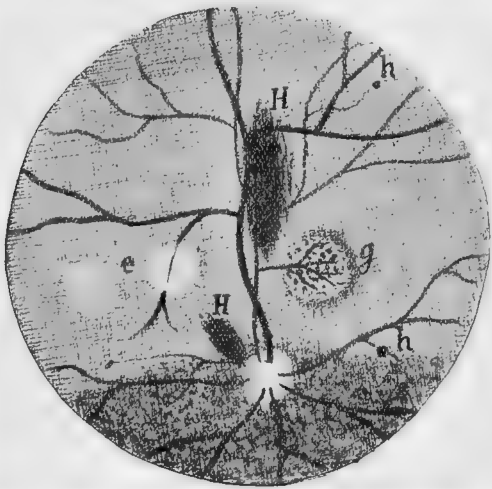


Fig. 115. Lesions of retinitis in an ox.

e, White spots of exudate, one of which covers a vessel and has caused it to undergo atrophy. *g*, Patches of granulations with newly-formed vessels. *H*, Hæmorrhages having a flame-like appearance. *h*, Hæmorrhagic points.

Albuminuria and diabetes produce retinitis in man most frequently and in the most characteristic form. But we know nothing as to these diseases affecting the retina in animals.

Intoxications are capable of giving rise to retinitis. Blindness may supervene in dogs after the ingestion of from 15–45 grammes of the æthereal extract of male fern, and

vascular and nervous alterations can be recognised (Masius and Mahaim).

By experimental concussions to the eyeball, Berlin and Denig have caused lesions of the retina in rabbits consisting of hæmorrhages and a milky cloudiness of the membrane, visible with an ophthalmoscope. The milky cloudiness was constant and seen at the point where the blow was struck and directly opposite to it, disappearing in a few days.

Prognosis. The lesions of retinitis are always serious, for they are accompanied by a diminution in the power of vision proportional to their extent and situation; they may be complicated with retinal and papillary atrophy.

Treatment. The cause must first be treated; then an attempt should be made to provoke the resorption of exudates with iodide of potassium, purgatives, and diuretics.

Hæmorrhages of the Retina. It is not absolutely rare to meet with hæmorrhages of the retina in animals, and in most cases they are easy to recognise. If only slight they remain intraretinal, or they may be between the retina and the vitreous humour, or between it and the choroid. In these cases they look like points, flakes or flame-like patches. Hæmorrhagic *points*, well circumscribed, about the size of a pin's head or more, bordering on the capillaries from which they are derived, are intraretinal. The *flakes*, varying in size, with irregular margins, are most commonly on or under the retina; they are seen in the spaces between the vessels as well as in their field. The flame-like patches are situated in the immediate neighbourhood of the vessels, running parallel to them, longitudinally striated and frayed at their terminal extremities, characters which suggest their being localised in the layer of nerve fibres (Fig. 115).

The *colour* of these retinal hæmorrhages depends on their thickness and age; red or brown according to their thickness when recent, they become pallid during resorption and take on a yellow or grey tint. Resorption is sometimes very slow. Schindelka, in a dog found yellow-grey spots at the places

hæmorrhage had occurred six months before. When somewhat extensive they are often accompanied by a slight haziness of the corresponding region of the vitreous humour.

When hæmorrhages are abundant the blood breaks into the vitreous humour which it more or less invades; it may then be impossible to illuminate the eye, and though the diagnosis of hæmorrhage into the vitreous humour is as a rule easy, it is impossible to determine the source of the blood with any certainty.

Any cause diminishing the power of resistance of the vessel walls or increasing the blood pressure may cause hæmorrhage of the retina. It is seen in :—

Retinitis, as has already been mentioned. In man the name hæmorrhagic or apoplectic retinitis has been given to a form which is characterised by common occurrence of hæmorrhages. The prognosis of this form is serious for it is frequently complicated by increased tension (hæmorrhagic glaucoma). Eversbusch saw hæmorrhagic retinitis in two dogs, one of which died of scorbutus. In cases in the dog also, Schindelka saw the retina crammed with hæmorrhages and attributed the lesions to ptomaine poisoning. One of the animals attacked being watched for a year, he observed no modification in the intraocular pressure, but there was complete blindness.

Papillary stasis and *papillitis*, which will be dealt with later.

Traumatisms reaching the eye directly or indirectly. In the horse in consequence of falls, Fritz and Müller saw the tapetum lucidum marbled with blood and the deep parts of the vitreous humour invaded. Walther observed two well defined hæmorrhages the size of a hempseed on the nasal border of the papilla. Following on a contusion of the eyeball Guillaumin recognised a peripapillary hæmorrhage, first of a gooseberry red colour, becoming paler and scattered into points of pigment, which were resorbed in a few weeks. In a cat which had been struck in the eye by a stone, Eversbusch noticed besides retinal hæmorrhage, rupture of that membrane and also of the choroid.

Albuminuria, *septicæmia*, *diabetes*, *jaundice*, *phosphorus poisoning*, *arterio-sclerosis*, and *heart diseases* in man. These last affections cause emboli and thrombi of the central vessels of the retina. As complications, or rather as simultaneous affections, may be mentioned irido-cyclitis (Guillaumin), optic atrophy (Walther), amaurosis (Schindelka). Treat with potassium iodide, diuretics and purgatives.

Atrophy of the Retinal Vessels. Anæmia and ischæmia of the retina in man usually arise from atrophy of the retinal vessels, which disappear completely or only leave whitish sclerosed filaments on their course. The retina keeps its transparence, or it may show a haziness indicative of an anterior inflammation; at other times it shows pigmentary degeneration.

Total disappearance of the retinal vessels without trace of any white filaments constantly accompanies atrophy of the papilla in the horse, which is not, as a rule, the case in man.

Nicolas has never been able to appreciate degenerative alterations commencing in the retina with an ophthalmoscope. A case has been reported in a young sporting dog of double total atrophy of the retinal vessels, the animal gradually becoming blind without any apparent cause. Some peculiarities of the depth of the eye can be attributed to congenital anomalies (*See* Plate VII A and compare with Plate III).

In the two eyes the papillæ are absolutely white, with ill-defined borders and no trace of a vascular network. In the retina—completely transparent—or which perhaps was completely absent, no red or white filaments remain to indicate any previous circulation.

The complete absence of the tapetum allows the subjacent choroid to be seen. It is faintly pigmented, and only in the vascular interstices shows a very close network of white vessels, slightly yellowish and completely sclerosed; some which can be counted shew still at their centres a fine red line, witnessing to their much reduced permeability. The state of the fundus oculi was the same in both eyes. Left to himself the dog walked slowly forwards with his nose to the

ground until he met with some obstacle, and on running against anything he turned aside and repeated the performance. Although the animal was of no value the owner would not allow it to be examined post-mortem.

Intoxications may produce ischæmia of the retina. Becker and Eversbusch have caused it in a dog by the subcutaneous injections of quinine. It also results from prolonged compression. Baquis discovered that compression of the optic nerve and the ciliary vessels leaves the retina intact if it is not applied for more than thirty minutes. Beyond this time the vascular lesions are very marked, and invariably end in atrophy.

Detachments of the Retina. By detachment is meant a loss of contact between the retina and the choroid. A perfect idea of the phenomenon can be obtained by opening the eye of a healthy horse. As soon as an opening is made, the vitreous humour slips and tends to escape, and this simple movement is sufficient to displace the retina, which no longer remains contiguous with the choroid. First of all small whitish lines are produced, especially round the papilla, in the form of rays, which are really so many folds of the retina; then if the vitreous humour projects further out of the eye a greater or less portion of the retina will follow its course.

Symptoms. Clinically the detachment is either partial or total. If partial it is sometimes radiate, sometimes mammillated in nipple-shaped projections.

Radiate detachment is peripapillary; it is frequently observed in the horse as a complication of irido-choroiditis, sometimes in the initial stages, but more often in the atrophic stage. The radii, milky or yellowish-white in colour, about 1–1½ papillary diameters in length, surround the papilla like the points of a mariner's compass. (*See* Plate VIII). Since these are folds of the retina they have the form of pyramids, the bases of which are supported on the margin of the papilla, their summits being lost in the ground of the retina.

Their prominence in the vitreous humour is at once appreciable by the method of parallatic displacements which apparently makes the fold displaced at each movement of the observer; also by the shadow which these prominences throw on one side or the other according to the direction of the illuminating rays; and lastly by the difference in refraction existing between these folds and the rest of the retina, a difference which may be found to be one, rarely two dioptries, corresponding to a prominence of 1–2 millimetres. Nicolas and Mouquet have seen these radiating peripapillary folds

Fig. 117. Mammillated retinal detachment in man. *d*, *d*, Detached portions. *m*, Macula lutea.

disappear by the reposition of the retina in proportion as the choroidal exudate became resorbed, but they are often only the commencement of larger detachments.

Mammillated form. This form is very rare in the horse, in which, however, Schimmel has seen it, as have Schindelka, Möller, and General Smith, but in man it is very common.

Nicolas has seen it in the dog. The detached portion of the retina, which is of a bluish-grey tint, forms large rounded folds resembling the contour of an undulating country.

In dogs, as in man, the long vessels of the retina follow the folds of the membrane and show interruptions in their continuity: quite visible in one place on the top of a fold, they disappear in another, being at the bottom of a furrow between two more folds (*Vide* Plate VIIIA). Still more marked than in man is the contrast existing in animals between the bright colours of the tapetum and the grey dull non-reflecting parts of the detached portions of the retina; but if the detachment is extensive it may happen that the observer, using the direct method, cannot at first make out the exact positions of the parts, for the detached retina, highly hypermetropic, cannot distinctly be seen. In these cases the use of convex lenses is necessary to obtain a good view of the region. Or attention may be drawn to the undulations in the detached part of the retina when the eye is moved (Schindelka, Möller). [Smith has observed it to wobble about at the bottom of the chamber with the movements of the eyeball]. Finally it may happen that these nipple-like projections are visible at a distance and give the pupil a greyish white reflection—called "amaurotic cat's eye."

Total or infundibuliform detachment. This is frequent in the horse in irido-choroiditis with phthisis bulbi. The retina has then an infundibuliform appearance with its lesser extremity attached to the papilla and the larger attached to the ciliary body. In this form the lesions belong rather to the province of pathological anatomy than to clinical work, for they are usually produced at a time when the eye is no longer able to be illuminated.

Nicolas has, however, in two cases been able to diagnose the condition with an ophthalmoscope in young remount horses, the eyes of which had not undergone atrophy, but showed exudates into the vitreous humour.

Neither the tapetum nigrum nor the tapetum lucidum could be recognised; the mirror illuminated the interior of a funnel

the walls of which were formed of segments of a cone, like those composing the corolla of a convolvulus flower, in such a manner that between each whitish mammillation there was a deeper coloured depression.

In consequence of this disposition the papilla appeared hollowed out at the bottom of a fluted funnel. The retinal vessels could no longer be distinguished.

Extensive detachments of the retina are often accompanied by opacities of the vitreous humour which make an ophthalmoscopic examination difficult.

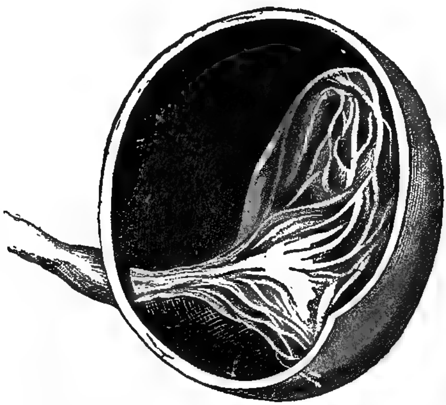


Fig. 118. Total infundibuliform detachment of the retina of a horse (Bayer).

[This form of detachment is common in the cat; both eyes may be attacked at the same time. It may readily be recognised without the aid of an ophthalmoscope].

Etiology. Detachment of the retina is a lesion occurring with irido-cyclitis and irido-choroiditis in horses: Berlin has seen it in the horse in 18 out of 21 eyes examined. Richter and Mayer also have recorded it in the horse as a congenital lesion occurring with other lesions of the same nature. Schulz and Strübing have recognised a complete detachment of the retina in both eyes of a dog suffering from experi-

mental diabetes. Nicolas has observed a case in a dog, attacked with spontaneous diabetes, which had at the commencement of the disease, a cataract in the same eye. [Handcock and Coats found detachment of the retina in four out of six cases of tubercular choroiditis in the cat; it occurred comparatively early in the disease]. *

In man traumatisms, tumours of the choroid, cysticerci under the retina, and hæmorrhages into the vitreous humour cause this condition : in some cases it is spontaneous, or no well defined cause can be found. By injecting blood into the vitreous humour of a rabbit Pröbsting observed two facts which he attributed to the resorption and organisation of the clot; a detachment of the retina and an image with the ophthalmoscope which resembled that described under the head of *retinitis proliferans* in man, the pathogenic origin of which he tried to explain. Detachment of the retina has also been observed in the pig (von Hymenn), and in a pigeon (Friedberger).

Pathological Anatomy and Pathogenesis. In every detachment of the retina the vitreous humour can be seen in front of the retina, more or less opaque and atrophied; behind, between the retina and the choroid, the space is filled with a serous, fibrinous, or hæmorrhagic fluid. The retina may be macroscopically intact, pierced with holes, or ruptured. From these facts two theories arise: that of retraction of the vitreous and that of subretinal exudation, both of which are applicable in certain cases.

In the peripapillary radiate detachment seen in the horse at the commencement of an attack of irido-choroiditis and at length disappearing by reposition of the retina, it seems that exudation from the choroid plays the chief part. In extensive infundibuliform detachments, on the contrary, retraction of the vitreous humour must surely be the cause. On post-mortem examination the vitreous humour is seen to be shrivelled, its liquid portion is expressed under the influence of the retraction of the exudates which penetrate it; the solid

* *Veterinary Record*, Vol. xxiii., p. 434, Jan. 14th, 1911.

part remains adherent to the ciliary body and drags the retina forward, because the fibrinous exudates join the two structures together; the liquid part passes through the retina either by filtration or more easily through ruptures, which soon appear in it, and forms the fluid under the retina.

In hæmorrhages it is still the retraction which acts; it may be the same in diabetes, the sugar withdrawing the water from the vitreous humour, etc.

Prognosis. Detachment of the retina is a serious lesion. The accompanying loss of sight is due to opacities in the vitreous humour; the traction on the retina causes photopsia or subjective light sensations; the inequality of the surface on which the images are formed causes these images to be distorted (metamorphopsia); complete detachment produces blindness.

Treatment. The detachment itself is as a rule inaccessible, and the cause must be sought for. In man, in cases of tumours of the choroid, or of cysticerci, enucleation is practised. The extraction of the parasite by an incision in the sclerotic has also been tried, and the eyeball saved.

Tumours of the Retina. *Cystic degeneration of the retina.* Cystic formations, about the size of a pea and looking like hemispherical tumours, are met with in the retinæ of aged animals. They are well circumscribed, motionless, perfectly transparent, and allow the subjacent choroid to be seen; their predilection seat seems to be in the neighbourhood of the ora serrata, but they are also met with on the posterior face of the ciliary body.

Eversbusch diagnosed this condition in a horse 24 years old, with an ophthalmoscope. He also saw them in an ox, and Merkel recognised a case in a dog.

These senile alterations are somewhat like those seen in man. They are produced by the regression of the cells of the external molecular layer (Greeff). Willach states that the contents of a cyst of the retina of the horse had the appearance and consistence of the vitreous humour. Cysts formed by cysticerci are met with in the retina in man.

Sarcoma. Among other tumours the only record is one of a case of round-celled sarcoma in the retina of a horse, by Born. After filling the ocular cavity the tumour perforated the cornea and proliferated outside. Bayer doubts whether the retina was the starting point of this growth.

In man the malignant tumours of the retina are gliomata. It is disputed whether they are sarcomatous or true nerve-tumours.

Congenital anomalies. Opaque nerve fibres or myeline fibres come under this heading, and they must not be confounded with the white patches of retinitis; they are described on p. 105; also the coloboma of the macula lutea (?) of the rabbit described by Hess. In this case in both eyes a quite well-defined white patch could be seen, the diameter of which was several times that of the optic papilla.

Diseases of the Optic Nerve.

Neuritis. Optic neuritis or inflammation of the optic nerve may attack the terminal extremity of the nerve and be visible at the papilla—this is intraocular neuritis or papillitis. On the other hand, it may be situated at some other point on the course of the nerve: this is retrobulbar neuritis, which can be suspected in man from a chain of subjective symptoms, but which cannot possibly be diagnosed in veterinary practice unless it descends as far as the papilla.

The inflammation is never localised exclusively to the papilla: there is always neuroretinitis or retinoneuritis. When the inflammation starting in the retina spreads to the disc and to the optic nerve, the neuritis is said to be *ascending;* on the contrary, it is *descending* if the inflammation starts in the optic nerve to extend to the retina. But this division is anatomical rather than clinical.

Intraocular Neuritis or Papillitis.

Papillary Congestion and Simple Neuritis. The papilla is blurred and of a uniform red tint. The margins are ill-defined, sometimes quite indistinct, and the papilla is indistinguishable from the retina. The veins are fuller and more tortuous, the arteries are thinner. In consequence of the

repletion of the vessels the retina becomes infiltrated and less transparent. Normally cupped, the papilla becomes filled up and may even project into the interior of the eye, a condition which can be recognised by its being hypermetropic in comparison with the neighbouring regions.

The redness of the papilla varies normally in different individuals in the horse, so that a diagnosis of papillary congestion should not be made without comparing the suspected eye with its fellow, and also there should be at the same time a diffuse disturbance of the various regions.

Papillary Stasis, Papillœdema or Strangulated Neuritis. [This was formerly known as "Congestion papilla," "Choked disc," or by the Germans "Stauungspapille," but since its pathology has been better understood these terms have been abandoned]. In this form the papilla and the neighbouring retina are the seats of a true œdema. The tumefied papilla can only be recognised from the emergence of the vessels, and stands out into the vitreous humour like a greyish-white mushroom, streaked with greyish-white radiating lines, the margins of which bend down to reach the level of the retina some distance from the circumference of the disc. The vessels lost in this gelatinous-looking mass are hidden from place to place, whilst here and there they are dilated and sinuous. It is especially the veins which are seen, engorged with blood and blackish in colour, the arteries being filiform and more red. In animals in which the vessels start from the centre of the papilla they can be seen to describe a curve as they pass from the papilla to the retina.

These changes are the result of an embarrassment of the circulation in the intrascleral portion of the optic nerve. The arteries, their walls being more resistant, still allow a little blood to pass, but the veins cannot do this because of the compression which takes effect more easily on their thin walls. Under these conditions papillary and retinal hæmorrhages are not readily observed.

Papillary hæmorrhages without any other inflammatory symptoms have been met with in the horse, by Bayer, follow-

ing on a fall, and by Dupuy as an ocular symptom of an abscess situated in the white substance of the corresponding frontal lobe.

Etiology. Certain intraocular affections—retinitis, choroiditis, and almost invariably irido-choroiditis and irido-cyclitis, are accompanied by the simple form of papillary neuritis.

Intraorbital lesions of the optic nerve may cause it, as has been shown by experiments on rabbits. By ligaturing the nerve Adalbert Russi saw the following interesting symptoms developed, giving some idea as to the course of papillitis: (*a*) The period of anæmia of the papilla and of the retina, characterised by a constriction of the veins and arteries, which become extremely pale and can no longer be distinguished from one another; (*b*) the period of stasis of the veins of the retina with œdematous infiltration of the papilla, disappearance of the infundibulum of the nerve, and an interruption of the column of blood in the retinal vessels; (*c*) a bright pink colour of the papilla with, in some cases, the appearance of small hæmorrhages and the formation of small vessels; (*d*) the period of atrophy; capillary hyperæmia ceases, the papilla at first assumes a whitish tint, then a bluish-white mother-of-pearl colour, while the vessels which before were dilated and flexuous become thin, pale and straight. This stage of atrophy is sometimes accompanied by pigmentary deposits and small atrophic foci in the neighbouring parts of the retina and choroid. These facts have been experimentally confirmed by Redard and Vennemann.

Schindelka saw papillary stasis in a horse which on post-mortem was found to have a metastatic intraorbital effusion enveloping and compressing the optic nerve.

Intracranial affections are mostly incriminated. Bouchut* first showed experimentally that cerebral apoplexy may cause symptoms of papillary stasis in the dog. Later, he found the same lesions in a sheep suffering from cerebral cœnurosis. With this last fact should be mentioned the case by Boschetti

* Atlas d'Ophtalmoscopie Médicale et de Cérébroscopie, Paris, 1876.

of papillary stasis seen in an ox, which showed echinococcus cysts in the cerebrum.

In the horse, papillitis has been seen by Hubrich following on hæmorrhage and softening of the brain, by Heintrich after an attack of vertigo, and by Wolff as a symptom of sarcoma of the hypophysis (pituitary body). Nicolas and Fromaget observed a well-marked case of double stasis with œdema and hæmorrhages of the retina in a blind cat which had a cranial tumour deforming the base of the nose and embarrassing respiration (*See* Plate IX). [Tuberculosis of the cerebral meninges, and other structures, often gives rise to similar conditions in all animals].

In man, whatever may be their position or size, intra-cranial tumours give rise in 90 per cent. of cases to symptoms of papillary stasis or to descending neuritis with primary optic atrophy.

[Double papillitis without failure of sight and without other changes in the eye was first described by Hughlings Jackson, and is a very valuable objective sign indicating the presence of intracranial tumours or inflammation in man].

Amongst diffuse affections of the brain causing papillary neuritis, Peters and Heyne mention hydrocephalus in the horse, and Uebelen cerebro-spinal meningitis in the ox.

Deutschmann has shown experimentally in the rabbit that infection of the meninges may be manifested by simple papillitis or venous stasis. Without too greatly exaggerating the importance of ophthalmoscopic investigation in cerebral affections, as Bouchut has done in introducing cerebroscopy, it may be said that no observation concerning these affections can be complete unless a systematic examination of the deep membranes of the eye be made. Nicolas therefore advises all veterinary surgeons to practise this method, for if any advance is to be made in cerebral pathology in animals, it is certain that ophthalmology, and ophthalmoscopy in particular, will greatly contribute to this end.

Papillitis has also been recognised by Bayer in a horse suffering from a cardiac affection; by Schlesinger and Möller

in the horse, Bayer, Schlampp, and Westrum in the dog, in cases in which no cause could be discovered. [In the horse an amblyotic state of the eyes has been observed in Australia from ingestion of native tobacco plant. On post-mortem of such cases the pathological change found was retrobulbar neuritis]. Lastly it may be mentioned that in man intra-ocular neuritis is met with in injuries to the cranium, infectious diseases, and chronic affections; albuminuria, diabetes, scrofulosis, and anæmia; during pregnancy in women; in poisoning by lead, alcohol, or iodoform.

Prognosis. Atrophy of the optic nerve is the most serious and frequent termination.

Treatment. This should be first of all directed towards the removal of the cause. Locally, bleeding, [leeches, blisters], and setons, may be tried. Purgatives and diuretics should be given, together with resorbents. Diaphoretics are given in man.

Atrophy of the Optic Nerve. *Symptoms.* The optic disc in the horse no longer shows distinct zones, it has a uniformly white appearance, with, at its centre, grey or yellowish spots, which are portions of the lamina cribrosa. The margins of the papilla are well marked when the atrophy is descending or follows an affection of the optic nerve; indistinct, diffuse, and confounded in places with the retina when the atrophy follows an intraocular, retinal or choroidal affection. The vessels of the retina are almost completely absent in the horse in total atrophy; they are more or less shrunken and rarefied in partial atrophy. The papilla mostly preserves its normal dimensions, but it appears sometimes reduced, on ophthalmoscopic examination, to the dimensions of a sixpence. In other animals in which there is a complete retinal circulation, the retinal vessels are often only diminished in calibre, as in man.

In a case of double optic atrophy seen by Nicolas in a dog, the papillary network and the retinal vessels had completely disappeared.

The papilla may be more cupped out than normally, and such a case has been seen by Eversbusch in a dog, and by Möller in a horse.

Atrophy of the optic nerve almost constantly causes blindness in the affected eye; but it is not necessarily accompanied by dilatation of the pupil as is usually stated, unless it be double.

Pathological anatomy. There can be distinguished, from this point of view *simple atrophy* of the nerve fibres which means that the diameter of the nerve may be very much reduced as in a case reported and illustrated by Möller, and *inflammatory atrophy* where the atrophy of the nerve elements is the result of a hyperplasia of the interstitial connective tissue compressing and stenosing the fibres and vessels as in cases mentioned by Westrum in the dog, and by Peters, and Mouquet and Benjamin in the horse.

Atrophy of the nerve is accompanied by atrophic lesions of the retina. This has been proved by Hertel who showed by experiment that six and twelve months after the section of the nerve there is complete atrophy of the layer of the nerve fibres, disappearance of the ganglion cells, a slight wasting of the supporting fibres, slight alterations of the layer of rods and cones, with integrity of the molecular layers. The affected eyeball is smaller than its fellow.

Etiology. Atrophy of the optic nerve has been often seen, particularly in the horse and dog; reported causes are: Intra-ocular affections: retinitis, choroiditis, and especially papillitis. In some cases of diffuse choroiditis seen by Nicolas in horses the affection was always accompanied by papillary atrophy.

In Plate V an example of complete atrophy is given and another of commencing partial atrophy which were both due to this origin. Choroiditis and choroido-retinitis should also be mentioned as causes according to Rémond, who states that in one case in which the diffuse appearance of the margin of the papilla in the presence of fine pigmented tracks starting from the choroidal patch and invading the

papilla in the direction of the nerve fibres, seemed to indicate fairly clearly that the exudate had made its way from the choroid and retina to the optic nerve.

On the other hand Möller, and Vennerholm report cases seen in the horse in which the papillary atrophy followed on peripapillary cystic formations, which will be described later.

Amongst *intraorbital* affections leading to immediate atrophy, Möller mentions an inflammatory tumefaction consequent to parotiditis. In two cases of amaurosis in the horse with atrophy of the papilla and exophthalmos, Thomassen incriminated sphenoidal sinusitis.

In man *intracerebral* affections: lesions in the brain, tumours, hæmorrhages, as well as diffuse alterations may cause optic atrophy. Three observations by Payrou, of which one was examined post mortem, show that the same may be the case in the horse. In the three cases the atrophy was consecutive to falling on the head, more particularly on the neck, either from hanging back and breaking the halter shank or from rearing. Cerebral symptoms were also seen: stupefaction, coma, vertigo, rotatory movements, and motor inco-ordination. In one of these cases ending in death, in which double atrophy was complete on the fourth day, there was also ptosis of the upper eyelid, divergent strabismus and mydriasis. Post mortem discovered a fracture at the junction of the basi-occiput and the sphenoid, meningeal ecchymoses, an effusion of blood at the depth of the interpeduncular fissure involving the third pair of nerves and the optic chiasma.

Among the general diseases may be mentioned great loss of blood (Möller, Walther), heart affections (Peters), influenza (Schindelka), distemper (Liebenger), and polyuria (Noack).

Experimental intoxication with morphine causes pallor of the papilla (Laborde), æthereal extract of male fern optic atrophy (Masius), ligature of the bile-duct may cause neuroretinitis, hæmorrhages, and alterations of the choroid (Dolganoff), by hydrochloride of quinine, ischæmia of the retina (Barabaschew), etc.

Double atrophy occurring in the dog and progressive in its course, without appreciable cause, was seen by Eversbusch in seven King Charles spaniels—both parents and offspring, suggests hereditary influence.

Prognosis. This is very grave, blindness always resulting from atrophy.

Treatment consists in combating the cause, if possible. If this cannot be determined, or if it cannot be directly acted upon, give iodide of potassium internally. Not much hope of recovery should be entertained.

Peripapillary Cystic Formations. In the horse, somewhat rarely it is true, small formations, usually pear-shaped, sometimes bilobate, are met with; their pedicles are towards the papilla, and the free portions advance under the retina, which they raise up, as is shown by the deviation of the vessels of this membrane (*See* Plate VII, Fig. 1 and Plate VIIB, Figs. 1 and 2). About the size of a pea by the upright image, white in colour, and not transparent, they give the impression of being small pedunculated cysts. Bayer has seen six or seven round the same papilla, but they may often be isolated (Nicolas and Fromaget, Joly). In no reported cases do they seem to have interfered with vision.

As no anatomical examination has been made they may be compared to those of the same class observed in man under the name of *hyaline or colloid outgrowths of the Optic Disc.* The symptomatic resemblance could not be more marked, for Panas thus describes them: "As a rule these productions are situated on both sides, but they may be single or combined with those of the choroid. They are attached to the periphery of the papilla, where, in multiplying, they form a sort of rosary resembling stalactites, as Masselon has remarked. Placed under the vessels they raise them up and fold back the pigmented ring which surrounds the optic disc, and according to whether they are more or less prominent, they appear white or grey. Their distinguishing feature is the fact that however numerous they may be they do not affect the vision."

From histological researches made on man by Gurvitsch it

seems that these conglomerate structures are formed right in the nervous tissue, and that they are independent of the vessels. They are formed of a mucilaginous tissue without proper structure.

Möller, Vennerholm, and Bayer have published and illustrated descriptions of other observations on horses which Nicolas considers should be classed with these affections although the authors attribute them to neuro-retinitis. They differed, however, in their gravity. In Möller's case the cystic productions were very much developed and turned back on the papilla, completely masking it, and forming a nipple-like tumefaction projecting into the vitreous humour. After three months they diminished in volume and after a year they disappeared, but there was total atrophy of the papilla and of the optic nerve for about three centimetres, when the eye was examined post-mortem by Virchow. Vennerholm published an observation in which atrophy seemed to have been caused by small tumours. Bayer was unable to follow up a case in a horse which was quite blind.

Affections of Vision without appreciable Lesions.— Amaurosis. This term, synonymous with blindness, is usually applied to the effect of different causes, visible in the eye; but, for example, in man we know that cerebral affections, neuroses, such as hysteria, neurasthenia, intoxications, etc., are sometimes betrayed by loss of sight, although the eye is absolutely normal in its membranes and media: under these conditions, taking the effect for the cause, it is also said that there is amaurosis. This blindness without appreciable lesion may be permanent, for example, in cases of inflammation of the brain and its membranes, tumours or softening; or they may be temporary, as in hysteria, neurasthenia, and intoxications, uræmia amongst others. When amaurosis is permanent it is possible that the lesion, at first hidden, may be shown later in the form of papillitis or papillary atrophy, both consecutive to a descending neuritis. On this account the diag-

nosis of amaurosis needs several successive ophthalmoscopic examinations [even, in many cases, carried over several months], if the cause is to be determined.

Amaurosis has been recognised in veterinary medicine a great number of times, but almost always as a symptom; the observers not having examined the ophthalmoscopic condition of the eye, their observations have but little interest. It may be mentioned, however, that the most commonly reported causes are, as a rule, affections of the central nervous system, hæmorrhage, injuries to the head, or intoxications. [In the dog it often arises during the later period of distemper, especially after the sudden spontaneous cessation of a persistent diarrhœa. It is also seen in the bitch following an early suppression of the "heat" or sudden loss of milk, or after hysteria].

In man the diagnosis is more easy, allowing that the subject has no interest in simulating the condition; but should this be the case the ophthalmologist possesses numerous methods of showing up the pretence.

In animals we have nothing to fear under this head, but the diagnosis of amaurosis is more difficult, and it may be well to mention a few points about this condition which is often decided upon too quickly without all the possible means of verifying it being taken. In any case the expression, the action of recognising things and places with the nose by smelling at them, which is common to all animals whether their sight is good or not, the high step, hesitating walk, etc., are, in the opinion of Nicolas, signs of no great importance if they are not confirmed by obvious objective proofs which are less liable to wrong interpretation (*See* p. 93).

What has been said in this respect regarding amaurosis may be repeated *a fortiori* with regard to amblyopia, nyctalopia and hemeralopia, defects of vision described elsewhere (p. 92), in the diagnosis of which it is impossible to have too many proofs.

[*Treatment.* This is subservient to the cause of the amaurotic condition of the eyes, which in many instances appears quite suddenly after an infectious disease, during pregnancy or some gastric or intestinal disorder.

If due to acute retinitis, optic neuritis, embolism of the central artery, cerebral hæmorrhage, thrombosis of the venous sinuses or infection of the optic tract or centres venesection to lower blood pressure, should be carried out and purgatives and large doses of potassium iodide given. In the very early stage leeches to the conjunctiva or the shaved skin of the eyelid, a seton at the nape of neck, or a blister over the cranium might also be tried. In the case of stomach or bowel trouble a dose of physic, or a subcutaneous injection of arecoline, eserine or pilocarpine will generally remove the temporary amaurosis. In those cases in the bitch due to suppression of the "heat" emmenagogues should be tried.

When resulting from profuse hæmorrhage after castration, venesection, parturition or other operation or accident, the subcutaneous injection of normal saline solution and of digitalis should have a trial. If arising during pregnancy, no violent treatment should be adopted until after parturition, when the sight is often restored without any treament. When appearing during or following an infectious disease, such as strangles, distemper, or influenza, the polyvalent antistreptococcal serum, aspirin, sodium salicylate, or sodium chloride should be tried for some time before having recourse to large doses of potassium iodide and later on to arsenic and strychnine. The application of strychnine to a raw surface induced by a blister over the cranial region was highly recommended by many old authorities. Strychnine should not be used too early, as if the amaurosis be due to an undiscoverable acute inflammation of the optic nerve or optic tract, it would likely add fuel to the fire and defeat its object. Preferably it should be injected under the skin above the eyelid and repeated as often as is advisable even until its physiological effect is manifested. Several practitioners have reported successful results following the use of electricity, one pole

being placed in the region of the tail and the other pole above the upper eyelid or below the lower one.

When the amaurotic state of the eye arises from chronic changes of the retina, optic nerve, and brain, or from cerebral tuberculosis or tumours, no hope need be entertained, unless in the case of cerebral tumours or parasitic cysts, the removal of which may be attempted].

Congenital Anomalies of the Optic Nerve. *Abnormal prolongations of the lamina cribrosa* which are met with in the human eye (Masselon), standing out into the vitreous humour in the form of filaments or membranes, may easily be visible in the eye of the sheep, even in the adult animal (Rochon-Duvigneaud). They are probably traces of the embryonic pedicle of the vitreous humour remaining adherent to the papilla.

Coloboma at the entry of the optic nerve has been observed by von Hippel in a rabbit which at the same time showed a subpapillary coloboma of the choroid. Von Ammon saw the same in a sheep.

CHAPTER IX.

THE CRYSTALLINE LENS.

Anatomy.

The lens is a transparent body separating the aqueous humour from the vitreous, and situated immediately behind the iris in the midst of the zone formed by the ciliary processes where it is fixed by the fibres of the zonule of Zinn.*

The volume of the lens shows great variations according to the species. As regards the absolute volume, Emmert gives the following figures in cubic centimetres: 3.2 in the horse; 2.2. in the ox; 0.7 in the pig; 0.5 in the dog and cat. But it is more especially when compared with the volume of the eyeball that the volume of the lens is interesting, especially with regard to the operation for cataract. According to the Emmert, whilst in the human subject the proportion of the lens to the eyeball is as 1 : 18, the ratio is 1 : 16.3 in the horse (it may be 1 : 12.1 according to Matthiessen), 1 : 14.5 in the ox, 1 : 12.4 in the pig, 1 : 10.2 in the dog, 1 : 9.8 in the cat, and 1 : 10 in the rabbit. It can thus be seen that to give exit to the lens in the horse the corneal incision must be relatively much larger than that necessitated for its extraction in man.

The form of the lens also varies. Almost spherical in fishes, it is more or less flattened in birds and mammals in which it presents two unequal curved faces, the posterior being usually the most convex. It is only in felines, including the cat, that the anterior is more convex than the posterior. The different measurements of the lens are given in tabular form on page 6.

In all the mammals there is a nucleus which is harder and

* Synonyms: Suspensory ligament, ligamentum lentis, zonula ciliaris, zone of Zinn, zonula Zinnii.

more refractive than the superficial layers. The physical properties of this nucleus may sufficiently be differentiated to be sometimes visible in the living animal. The observer should therefore be on his guard against certain greyish reflections of the pupil visible with the naked eye which are perfectly normal, but which may be taken for opacities of the lens which do not exist.

Structure. The lens comprises a substance of its own forming the lens proper (the lenticular portion), and an enveloping membrane made up of the anterior and posterior lens capsules. These are elastic structureless membranes. The anterior is considerably thicker than the posterior in birds and in mammalia (Becker); it is also covered on its inner face by a layer of epithelial cells from which the fibres of the lens originate.

The lenticular portion comprises: (*a*) A framework of amorphous substance forming two stars, one anterior, the other posterior, the rays of which, 3 or 4 in number, alternate with one another. In some cases of cataract they are clearly differentiated from the rest of the lenticular substance. (*b*) Fibres, supported by their extremities on the radii of the stars as shown in Fig. 119. Their borders are crenated and fit into one another, forming in this way a mass of lamellæ like those of an onion. *Zonula of Zinn:* This is the suspensory apparatus of the lens (which leaves between its equator and the zone of the ciliary processes a narrow circular space): it is kept in place by fine structureless filaments directed radiatingly. They are given off from the hyaloid membrane on the posterior face of the ciliary body and are fixed on to the lens capsules near its equator, some in front, others behind, thus bounding a circular canal, triangular on section, called the canal of Petit. From an embryological

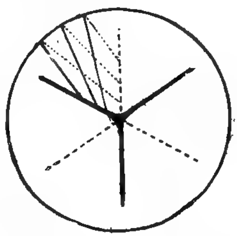


Fig. 119. Diagram of structure of the crystalline

point of view these fibres of the zonula of Zinn are dependences of the hyaloid membrane.

Nutrition. During fœtal life the lens is surrounded by a vascular membrane receiving its blood supply from the hyaloid artery (*See* Figs. 12, 13, and 14).

Nicolas in examining foals and dogs at birth has in all cases seen this membrane reduced to a few vessels in the foal, but still forming an actual network in puppies. Resorption only takes place in the days following birth. After

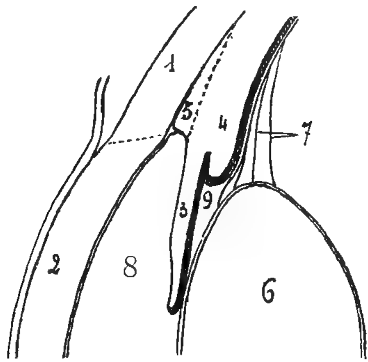


Fig. 120. Section of the anterior segment of the eye showing the fibres of the zonula of Zinn.

1, Sclerotic. 2, Cornea. 3, Iris. 4, Ciliary body. 5, Spaces of Fontana. 6, Lens. 7, Fibres of the zonula of Zinn. 8, Anterior chamber. 9, Posterior chamber.

birth, and when the resorption of the vascular membrane is complete the nutrition of the lens is effected by imbibition, either at the expense of the aqueous or vitreous humours, or of the ciliary body.

In all cases, as has been mentioned, alterations in the lens are an almost constant sequel to affections of the uveal tract. The function of the lens is to make the luminous rays, already rendered convergent by the cornea, converge still more towards the retina. But in order that this action may always

take place, and images may be formed on the retina whatever be the distance of the objects, *i.e.*, whatever the direction of the incident rays may be, the lens must be able to vary the curvature of its faces, to diminish or increase its thickness, or in other words to diminish or increase its convergent power.

This is accommodation, in which the lens on account of its elasticity is a passive agent and the ciliary muscle is the active one. To explain the mechanism two theories have been advanced: that of Helmholtz and that of Tscherning. They differ regarding the mode of action of the ciliary muscle.

As long as the lens is elastic, accommodation is perfect; but as the elasticity of the lens diminishes with age, as does that of the other tissues, a time comes when the lens cannot become sufficiently convex to allow of the sight remaining good. This is presbyopia, which usually begins to show itself in man about the age of 45 years. Animals, or at least the larger of the domestic animals, cannot suffer from presbyopia since their power of accommodation is insignificant.

Opacities of the Lens.

Cataracts. Opacities of the lens are known as cataracts. They may be situated on the capsule (*capsular cataract*), or in the lens itself (*lenticular cataract*). They may involve the whole mass of the lens, when they are called *total*, or may only exist in some points in the lens, being then called *partial*. Lastly, when a cataract is total the opacity may be more or less dense, when it is said to be *translucent* or *opaque*.

Objective symptoms. Diagnosis of the opacity. Though in animals in some cases opacities of the lens are easy to recognise, yet in a good many cases the word cataract should not be mentioned unless a sufficiently complete examination has been made. [General Smith states: "The eye in which I have most frequently found cataract, is one which from its external appearance is perfectly healthy, with a bright, transparent cornea, a freely moving iris, in fact no evidence of inflammatory trouble having at any time existed within or without"].

By the naked eye. Many horses, and still more dogs and cats, especially old ones, present on a naked eye examination a bluish or whitish reflection from the pupil which immediately suggests a cataract, though the lens is free from opacities and perfectly transparent. This phenomenon arises from the fact that the different concentric layers of the lens, commencing with the capsules, do not refract all the luminous rays, but reflect a certain number of them. These last rays are perceived by the observer, and give him a wrong impression as to the presence of an opacity.

The reflected rays are the more numerous, and consequently the appearance of the pupil is more bluish-white in proportion as the layers of the lens are more or less dense, which is always the case in the region of the nucleus, especially in old age, or more heterogeneous, which they become in certain congenital conditions to be described later. However familiar the appearance of the eye may be, and however little doubt there may be as to the presence of a cataract, it is always well to proceed to make a complete examination. [General Smith,* in (1896) speaking of cataract, says: "The diagnosis of cataract is, ordinarily speaking, a matter of great simplicity and certainty; it is therefore a deplorable state of affairs to read and hear of differences of opinion on a subject susceptible of absolute accuracy. . . . For many years past an instrument has been known, a glance through which is capable of settling with accuracy the existence or non-existence of opacities, and it does not redound to our credit as a profession that we have not adopted the ophthalmoscope more widely, but rather trusted to the black hat and our own often imperfect eyesight." The late Professor Axe stated that a cataract may be so extremely minute as to be absolutely invisible to the naked eye, so that the use of the ophthalmoscope was indispensable for the detection of the disease in its initial stage. The late Sir George Brown, among a very few others, would not, for many years back rely on giving an opinion on a horse's eye

* Journ. Comp. Path. and Therap., Vol. ix, 1896.

unless he had recourse to the ophthalmoscope. Until quite recently the general practice was to rely on the naked eye.* In the dog, however, one may readily make out the presence of certain cataracts by the naked eye in consequence of the wide dilatability of the pupil and the position one can place the animal in; one can in reality look down into the eye].

By direct illumination. This examination is made, as has been described, with an ophthalmoscope at a distance of 25–30 centimetres. Opacities of the lens are projected on the field of the pupil as black marks, because they form a screen to the rays coming from the fundus oculi. They are fixed, but move with the eye. If the cataract is total the pupil cannot be illuminated.

By lateral or oblique illumination opacities are whitish in colour or opalescent, since they reflect the luminous rays.

Diagnosis of the position. As a general rule lenticular opacities have a radiating striated appearance, notably in the dog, more rarely in the horse; or if they are central they appear to be in more or less regularly spherical masses, and are placed as sectors or segments of the circle if they are peripheral. Capsular opacities are on the surface, sometimes circular and central, more often irregular and without any special position.

For more precision as to the position of a cataract the following examinations may be made, giving more definite information.

By direct illumination. By movements of the eyeball. (α) Opacities of the anterior lens capsule are displaced in the same direction as the eye; (β) opacities of the posterior capsule are displaced in the opposite direction to the movements of the eye. This can easily be understood if it be remembered that the eye pivots round a vertical axis passing almost through the centre of the lens.

By the movements of the observer. (α) Opacities of the anterior lens capsule keep their relation as regards position

* *Veterinary Record*, Vol. xiii., 1900-1901, p. 87.

with the margin of the pupil whatever may be the direction in which the observer moves; (β) opacities of the posterior capsule do not keep this relationship but move nearer to the edge of the pupil towards which the observer displaces himself. If he moves to the left the opacity moves to the left edge of the pupil, and *vice versâ*, which, expressed in general terms, means that opacities placed behind the iris move in the same direction as the observer.

By lateral illumination. (α) Opacities of the anterior lens capsule are in the plane of the pupil or else form a convex surface which is only appreciable if they are of a certain size; (β) opacities of the posterior lens capsule are more deeply situated and form a concave surface, which is easy to recognise on account of the increased curvature of the posterior face of the lens.

[*By examination of the Purkinje-Sanson reflex images—the catoptric test.* Until it became generally known that the ophthalmoscope could advantageously be used with ordinary daylight in the examination of the eyes of the domesticated animals the catoptric test was much in vogue in veterinary practice for the examination of the lens for opacities. Although it is a simple test the greatest care is required in carrying it out, else minute opacities will assuredly be overlooked, or strings or spots of mucus on the corneal surface mistaken for cataract. To obviate this latter error, or when in doubt the observer should rub the cornea with the upper eyelid.

The principle of the method is described on pages 45 and 46. General Smith* says that "in applying the test the whole area of the lens should be examined both in a horizontal and vertical direction, and each reflection should closely be watched. In a healthy lens the image of the flame should remain sharp and single, but in a lens affected with opacity the least trace causes the image to blur and even become double as it passes over the opaque area or spot. It is therefore the blurred image which is looked for, and unless

* Journ. Comp. Path. and Therap., 1896.

great care is exercised it may readily escape observation, and it is only exhibited just at the position of the opacity "].

Subjective symptoms. These cannot directly be appreciated in animals, but are none the less interesting, as it is to a great extent on these that the prognosis of opacities of the lens are based. They are drawn from human ophthalmology.

The *muscæ volitantes* are caused by limited fixed opacities, that is, always occupying the same point in the visual field; they generally cause but little inconvenience, the subject soon getting into the habit of putting them aside. *Monocular polyopia*, or perception of several images of the same object, a result of irregularities of refraction, interferes with vision more seriously in some cases. *Diminution in the power of vision* should be specially enquired into. It depends (α) on whether the lesion is *diffuse* or *limited:* the sight is more defective when the opacity is diffuse than when it is limited, even if in the first case the opacity is less dense than in the second. For example, a glass covered with steam is impossible to be seen through, though a glass covered with an absolutely opaque network can be seen through (Fuchs). (β) *The position of the opacity*: the sight is bad in proportion as the opacity becomes more central.

A central opacity is a hindrance at all times, but the sight is better at night when the pupil is dilated and gives access by the transparent periphery of the lens to a greater number of visual rays (nyctalopia) [day blindness]. A peripheral opacity may pass unnoticed, especially in a bright light which causes miosis; but the sight becomes worse at night or in a bad light for opposite reasons to those in the preceding case (hemeralopia) [night-blindness]. (γ) The vision is worse in proportion as the opacity is more extensive or more concentrated. In total cataract the outline of objects cannot be made out, but the patient can still distinguish day from night.

[In practice, however, many hunters afflicted with cataract apparently see obstacles which they generally negotiate even if they don't clear them ; in fact, they go about their work as

if there were nothing amiss with their eyes. General Smith,* in speaking of cataract not necessarily causing imperfect vision, says: "If a collection of bodies like the corpora nigra are not capable of interfering with the completeness and sharpness of the retinal image, a cataract the size of a dot situated at any point of the lens in the axis of vision need not give rise to serious apprehension about the sight; and, as a matter of fact, there are many horses possessing apparently undeniably good vision the subject of cataract, the condition only being discovered when the animal is examined for soundness on changing hands." The position of cataracts in the centre of the pupillary opening does not, as one might imagine them to, cause a broken image of the picture to be projected on the retina when the pupil is contracted. This is supported by the fact that if one take the ordinary photographic camera, and accurately focus on the back plate the image of a candle, and afterwards place a small piece of paper in the centre of the lense to represent an opacity, one will find that it does not make the least difference to the sharpness of the picture, even when "stopped down" so as to represent a contracted pupil. Not until the artificial pupil is reduced to the size of the opacity does the image of the flame become blurred. An opacity must equal in diameter the size of the artificial pupil before the image becomes blurred. Smith's view has the support of Col. Butler's experiments and of the physicist, Lord Raleigh. It evidently agrees with the observations of numerous practitioners. Butler, in addition, found that a faint opacity invariably "blurs" an image, while a much larger and denser opacity has no effect].

Pathological anatomy. Capsular opacities are produced by deposits, which are inflammatory or hæmorrhagic in origin, most commonly situated on the superficial face but sometimes on the deep (*See* fig. 121), but the lens capsules themselves undergo no pathological alteration, in consequence of their tissue having no structure.

* Journ. Comp. Path. and Therap., Vol. ix., 1896.

The transformations which take place in the substance proper of a lens in which an opacity is forming have been studied by Becker in senile cataract in man, and recently in the horse by Mette. The nucleus, made of a harder substance, retracts by becoming sclerosed, causing the formation between it and the cortical layers of clefts which become filled with droplets of serosity. Although at this moment the fibres of the lens are still transparent, as is the serosity, the difference in the refractive indices of the two substances produces opacity. Then the fibres of the cortical substance disintegrate from contact with the serosity, and are transformed into fatty globules and end by forming an opaque medium (liquor Morgagni). It is possible that this liquid may be resorbed, and in the event of this happening the lens again becomes transparent. The cases of spontaneous recovery of cataract reported in man [and in the horse]* are probably explained by this fact. But more often the destruction of the fibres of the lens goes on increasing; to the more or less coagulated lenticular liquid are added crystals of cholesterin, forming plates which look like mica, or the yellowish calcareous deposits which are frequently seen in old cataracts in horses.

The lens affected with cataract may be resorbed without any atrophy of the eyeball. More or less complete resorption is the rule. Nicolas has occasionally seen in horses a non-luxated lens reduced by half, the intra-capsular resorption having affected a segment of the lens. In the free half of the pupil the capsule could be seen torn from its insertion, retracted and shrivelled, but not immediately adherent to the lens. As will be seen later the resorption of the lens is usual in young animals when the capsule is opened. During life the cataractous lens has a whitish or milky appearance, but on post-mortem examination it has an amber tint without any whiteness.

* Consult article on Cataract in Percivall's Hippopathology, Vol. iii, 1858, pp. 102—126

[*Consistence of cataracts.* In earlier life or when opacities rapidly progress, the cataracts are often soft or not rarely almost fluid in consistence, especially in the dog. The slowly growing or senile cataracts beginning and ending as nuclear are generally hard in consistence, no doubt due to the fact that with age the lens normally becomes hardened. Their degree of hardness may vary from that of wax up to that almost of bone. The cataractous lens during the earlier stage is often swollen and presses the iris forwards. This is termed an *intumescent cataract.*

Size of the cataractous lens. As age advances the lens usually increases in all dimensions, but as soon as it becomes the seat of opacity it is, as a rule, smaller than that in the normal state].

Course of Cataract. Certain opacities of the lens have no tendency to increase; these include congenital cataracts, anterior or posterior polar for example. [General Smith* says: "In the present state of our knowledge I do not see how we are going to distinguish between the opaque dots which are not going to extend and those which are; the balance of experience is that they will not extend, but in any case I am assuming they are congenital, which at present I believe the majority of cataracts to be. . . . It is certain that though some cataracts spread over the entire area of the lens the majority do not, but remain throughout the life of the animal as spots or dots of opacity which neither increase nor decrease in size. For some years I watched a small cataract which had a clear centre and gave the impression of becoming absorbed, but such was not the case; the clear area never increased in size, and I think it may certainly be stated as a positive fact that a cataract never becomes absorbed." Macqueen has seen a small cataract remain stationary for at least nine years.] Others may even be cleared up in time, as are capsular cataracts caused by

* Cataract in the Horse, by Veterinary-Captain Smith. *Journ. of Comp. Path. and Therapeutics*, 1896.

hæmorrhagic or inflammatory deposits. Opacities of the lens, properly so-called, as a rule increase, more or less slowly it is true, according to certain conditions which have not yet been determined in our animals. [The transparent lens may become completely opaque within twenty-four hours, but in many cases years elapse before the cataract causes absolute opacity.

Wm. Pritchard was of opinion that a cataract could form in a week, and Wm. Williams within ten days.* Such statements as these, however, are generally open to revision because unless a careful examination was made with the ophthalmoscopic mirror, small incipient cataracts, unobservable by the naked eye, would be overlooked. In the dog progressive cataracts are the rule rather than the exception. They often attack one eye first and afterwards the other. In the initial stage, before the sight is impaired, such a cataract is often termed an *incipient* cataract].

A cataract which progresses is said to be *ripening* or *maturing;* when the opacity has invaded the whole lens it is *ripe* or *mature*, and ready to be operated on; later on it is *overripe* or *hypermature*. At each of these stages it presents certain characteristics which allow the surgeon to defer the operation if the cataract is too recent, that is, if it is not mature, and to operate with more chance of success when it is mature; and in certain cases to give a less favourable prognosis when it is too old. Omitting these distinctions, which have not yet been described in veterinary medicine, complete total cataract only will be noticed.

In man, as long as the superficial layers are transparent, lateral illumination throws on the opaque part of the lens a shadow of the iris, the extent of which depends on the thickness of the transparent part. When the opacity is total the iris no longer throws a shadow.

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* *Veterinarian*, 1871, p. 626. *Veterinary Record*, Vol. xiii, 1900-1901, p. 87; *Veterinary Record*, Vol. xx, 1907-1908, p. 678; *Veterinary Record*, Vol. xxi, 1908-1909, p. 716.

AXE, The Horse in Health and Disease, Vol. iv., p. 119.

Clinical Forms of Cataract.

Capsular Cataracts. *Diffuse Capsular Cataract.* This form is common in the horse and [occasionally seen in the dog and in birds], in which it is caused by the deposit of exudates coming from the ciliary body. These are surface opacities, ill-defined, and usually situated near the centre of the capsule, particularly in the posterior.

Sometimes very thin and more or less indefinite, they give the idea, under the ophthalmoscope, of fine sections of the pith of an elder tree seen under a microscope, and they only interfere a little with the examination of the fundus oculi. These opacities rarely invade the whole extent of the capsule and can rarely be diagnosed by the naked eye. Although of pathological origin these capsular opacities have no tendency to increase, on the contrary, they may be partly resorbed. [General Smith has never been able to satisfy himself of the existence of capsular cataract in the horse. A capsular cataract is often described as a *false* cataract in contradistinction to a *true* or lenticular cataract].

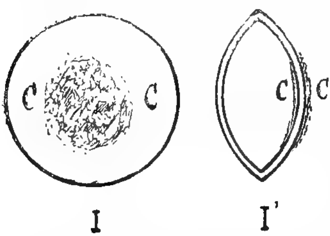


Fig. 121. Capsular cataract, seen in front *I* and in section *I'*.

Posterior Polar Cataract. This is as a rule well defined and stationary. It forms, in the horse, in which Nicolas has observed it several times, a circular opacity situated at the posterior pole of the lens.

In other cases this opacity projects into the vitreous humour in the form of a small cone, its base being towards the lens (*posterior lenticonus*), to the summit of which the hyaloid artery is sometimes attached, as has been seen by Payrou, sometimes a floating membrane—probably the remains of the vascular capsule of the lens. The lesion is often double. Posterior polar cataract seems to be explained by the fact

that it is fairly often co-existent with persistence of the hyaloid artery, of which it is a vestigial remain (Fig. 122).

Keil has seen it in a calf with microphthalmos and coloboma of the iris. From three millimetres in diameter and one in thickness, the point of the cataract only was adherent to the capsule and bound by fine filaments to the vitreous humour; it contained vessels surrounded by connective tissue when examined anatomically.

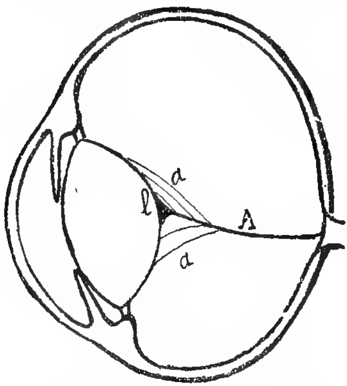


Fig. 122. Eye of horse. Lenticonus (*l*), and the hyaloid artery, (*A*). with fibrillary remains of the vascular capsule of the lens, (*a*).

Observations made by Hess on the pig and by Mulder on the rabbit in which there were, besides posterior lenticones (conical lenses), corresponding small ruptures of the lens-capsule have led these authors to think that the lenticones were consecutive to the rupture of the capsule. In Mulder's case the torn capsule gave passage to a small mass of the cortical substance which had the appearance of a lenticone.

In a case in a rabbit, reported by Back, of double lenticonus which he studied from an anatomical point of view there was no rupture of the lens-capsule, but on one side there was, as well as persistence of the hyaloid artery, an increase in the antero-posterior diameter of the lens, which caused him to form the opinion that lenticonus is due to a traction exerted on the posterior pole of the lens by the hyaloid artery in a state of evolution.

Anterior Polar Cataract. This is much more rare than the preceding form. It is a small, quite regular central spot 1–2 mm. in diameter. In man it may be a sequel to ruptures of the cornea; the alteration of pressure produced by the

escape of the aqueous humour leading to contact of the opening with the lens which becomes infected.

In a case of congenital origin, seen by Bayer in a horse (fig. 123), and histologically examined by Dexler*, the opacity was really situated in the layers immediately beneath the capsule *(subcapsular cataract)* and was formed by a vesicle containing the liquor Morgagni.

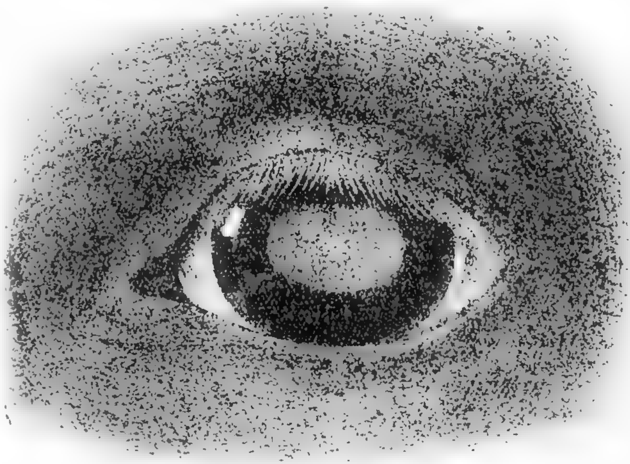
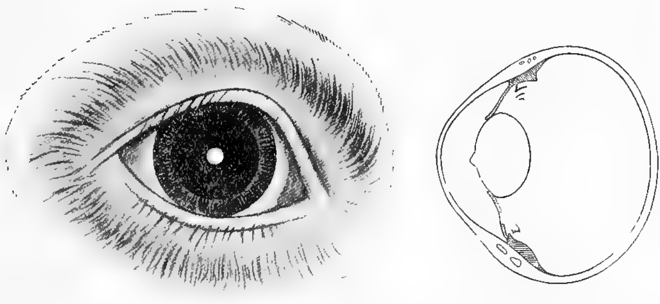


Fig. 123. Anterior polar cataract in the eye of a horse. (After Bayer).

[*Pyramidal Cataract.* This form of anterior polar cataract is sometimes seen in the dog and rarely in the cat. It appears as a small white spot in the centre of the pupil or at the anterior pole of the lens. When examined obliquely it seems as if slightly raised as a small eminence or pyramid from the lens. It arises from a perforation of the centre of the cornea and is associated with corneal opacity as a sequel of

* Monatschafte f. praktische Theirheilk. Vol. iii., and Tierärztliche Augenheilkunde, by J. Bayer, 1906, p. 360

purulent conjunctivitis seen so often when distemper attacks young kittens and puppies just before or shortly after their eyes are open. It remains fixed, rarely extending, and is wider and more densely white than is the congenital anterior polar cataract].



Pyramidal Cataract.
Front view. Section.

Lenticular Cataract.

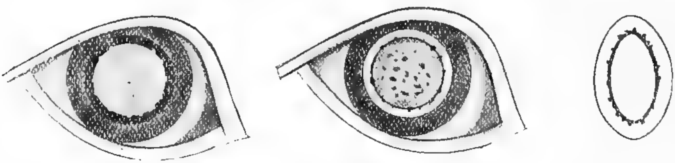
Partial Cataract. These opacities may be linear or of some size, irregularly placed in the substance of the lens, sometimes like scratches, and placed concentrically as seen in the horse, or radiating and rather towards the periphery as in the dog. [General Smith considers cataract in the horse to be more common towards the centre than towards the periphery of the lens].

They may be situated in the nucleus (*nuclear cataract*) or in the cortical layers (*cortical cataract*) or between the nucleus and the cortical layers (*lamellar cataract*). Total cataract is most often due to the extension and generalisation of these opacities.

[**Lamellar, Zonular or Perinuclear Cataract.** This form of cataract, frequently seen in children affected with rickets or convulsions, is occasionally encountered in the dog and in the horse. It appears as a greyish circular opacity in the lens, surrounded by a perfectly clear marginal portion. The nucleus is clear, but the opaque circular layer lies between

it and the superficial laminæ. Its progress is generally delayed for a long period, but may spread on certain occasions until it gradually develops into a total opacity of the lens. It mostly affects both eyes. But in an otherwise healthy eye of a foal, which showed no signs whatever of rachitis, Bayer found that the lamella lessened in density from the equator towards the poles of the lens, and the posterior lamella was in general more opaque than the anterior.

In a second case, an adult horse, Bayer observed that the posterior lamella was especially developed and intensely white, while the anterior one was only indicated at the upper periphery. The opacity is not often very dense but is well



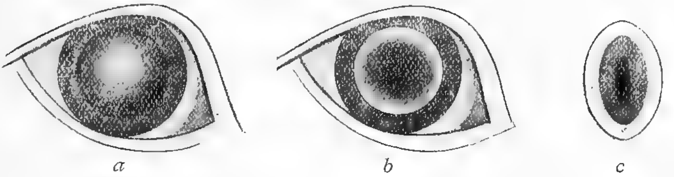
a *b* *c*

Lamellar, Zonular or Perinuclear Cataract. *a*, The appearance of the opacity viewed by oblique illumination; *b*, viewed by ophthalmoscope; *c*, vertical section of lens showing the opacity between the nucleus and the cortex, the centre of the lens being clear (Dog).

circumscribed and whitish and dotted over with white specks when viewed by oblique illumination. When viewed by the ophthalmoscope the opacity appears as a circle of almost uniform greyish or dark colour, at times with prominences, or darker dots. At the periphery of the opacity, which is generally well circumscribed, small opaque denticulations are not rarely observed standing out from the outline of the cataract and passing into the transparent outer zone, like the spokes on the steering wheel of a steamship.

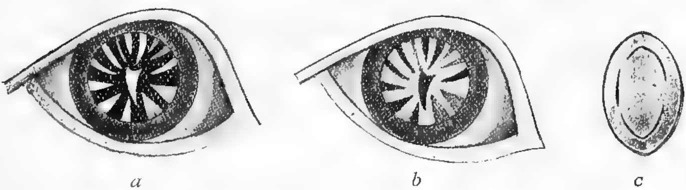
Nuclear Cataract. The opacity starts in the nucleus of the lens where it remains more dense, losing itself in all directions towards the cortex. The nucleus is intensely hazy rather than opaque. When viewed by oblique illumination the

opacity has a deeply situated yellowish haze if the cataract is immature. By the ophthalmoscope it appears as a dull blur in the pupillary area, deeper in colour at the centre, and gradually losing itself on all sides. The details of the fundus, if visible, are obscured.



Nuclear Cataract. *a*, The appearance of opacity viewed by oblique illumination; *b*, viewed by ophthalmoscope; *c*, vertical section of lens showing the opacity denser in the centre. (Dog).

Cortical Cataract. This opacity commences in the periphery of the lens and generally appears in the form of distinct lines, streaks, or triangular or wedge-like patches, which extend towards the centre of the lens and resembling somewhat the spokes of a cart wheel. These opacities generally start at the edge of the lens which is hidden behind the iris, but gradually reach



Cortical Cataract. *a*, The appearance of the opacity viewed by oblique illumination; *b*, viewed by ophthalmoscope; *c*, vertical section of lens showing the opacity in the cortex (Dog).

the pupillary field as whitish streaks or triangular patches. They occur in both the anterior and posterior layers of the lens, often leaving the intervening parts quite transparent. Ultimately the nucleus becomes involved and the whole lens

ends in becoming opaque. In the dog this form of cataract generally runs a rapid course, starts in one eye and ends up by attacking the other, so that the animal finishes up by becoming blind. When advanced the cortex is often fluorescent, having the glistening of satin or the appearance of mother-of-pearl or of flaky spermaceti. In some cases there

Posterior Polar or Capsular Cataract.

Posterior Cortical Cataract with fine radiations.

Placed side by side for comparison. (Dog).

may be numerous small dots or short streaks which are generally stationary. In others there may be a single large wedge of opacity or one or more dark streaks which, when seen by the ophthalmoscope, resemble cracks in glass. *Anterior* or *posterior cortical cataract* has a star or rosette like appearance with fine or coarse radiating lines, the centre

a *b* *c*

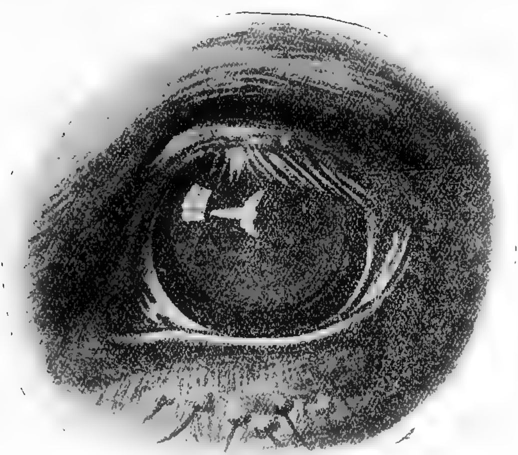
Posterior Cortical Cataract, with coarse radiations.

a, The appearance of opacity viewed by oblique illumination; *b*, viewed by ophthalmoscope; *c*, vertical section of lens showing the opacity in the posterior part of the cortex (Dog).

of which corresponds to the pole of the lens. The anterior or posterior polar cataract which shows itself in the form of a small central dot should not be confounded with either of these. Opacities in the cortex when small and confined to the edge of the lens are readily detected

in the dilated pupil by oblique illumination. In an advanced state they are easily seen in ordinary daylight. When viewed by oblique illumination the dots, streaks or wedges appear white or greyish, more or less distinct according to their position—anterior or posterior layers. With the ophthalmoscope they have a black or greyish appearance and are somewhat reduced in size. If the substance between the streaks or wedges be transparent, the details of the fundus can distinctly be seen.

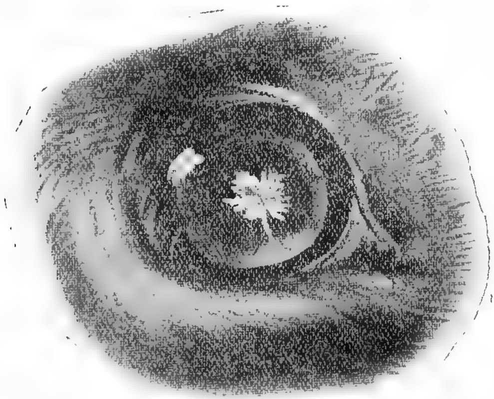
Bayer has repeatedly found, in horses, a congenital opacity in the form of a horizontal Y, which was snow-white and sharply defined from the remaining completely transparent lens-substance. In one case this opacity was combined with a spindle cataract, while a vertically standing opacity ran from the anterior pole of the lens towards the union of the three lines of the Y, as will be seen in the following figure:



Cataract of Horse. (After Bayer).

Bayer has also seen the Y-figure repeatedly in diseased and even in apparently otherwise sound eyes. When viewed by oblique illumination the lens was somewhat dull, like

"blind" glass, and iridescent; and the lines of the Y-figure appeared dark. The figure is not really Y-shaped, for the rays are joined much more in angles of 120°; moreover, one limb runs approximately horizontally, and from the anterior surface of the lens towards the external edge of the pupil, or from the posterior surface towards the internal edge. By the course of the limb one is in a position immediately to make out the situation of such a Y-shaped opacity (mnemotically—if the horizontal limb points *inwards* the opacity is situated posteriorly).



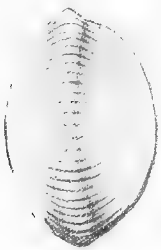
Cataract of Horse. (After Bayer.)

Bayer furthermore found in the otherwise quite sound eyes of a horse, at exactly the same places, a linear (—), sharply defined, snow-white opacity in the otherwise completely transparent lens. It somewhat resembled the remains of an anterior synechia; but such are never so very sharply defined, and are not snow-white, but more grey-white.

Bayer believes that one must regard this unmistakeable brilliant white colour as characteristic for congenital opacities; for one finds it in all other congenital forms of cataract with the exception of vesicular cataract, which is sufficiently characteristic apart from this.

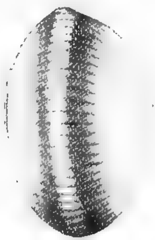
Bayer finally observed in a horse, in both otherwise sound eyes, snowflake-like snow-white opacities, the middle of which corresponded with the centre of the lens, as the figure on page 360 shows.

Naphthalinic Cataract. Experiments undertaken by Bouchard and Panas have shown that rabbits fed on naphthalin develop a cataractous condition of the lens. Magnus afterwards studied the question and found that the opacity can be seen within ten hours from the commencement of feeding with 3 to 4 grammes of naphthalin per kilogramme of the body weight. The first phase is the appearance of a number of very distinct striæ passing from the equator of the lens towards its pole. These striæ are found to be produced by little folds or depressions of various depths on the



a

Early stage of alteration of lens due to ingestion of naphthalin.



b

Later stage of lens induced by feeding on naphthalin.

surface of the lens. The lens fibres and epithelium appear normal and transparent and the ridges are evidently caused by shrinkage of the lens. When the lens is removed from the eye and placed in a hot chamber a similar appearance is manifested. This shrinking is shown in Fig. *a*.

The first phase is soon followed by a second—the stage of opacity, which always begins in the same parts of the lens, viz., in a zone immediately behind, and the other immediately in front of its equator. The posterior zone almost always shows the greatest degree of opacity, as seen in Fig. *b*.

The opacities, step by step, increase in breadth, spreading from the equator towards the poles. There is also a separate area of opacity to be observed at the posterior pole, and when this increases in area it joins that approaching from the posterior equatorial zone.

Should the naphthalin be discontinued in time, the opacities gradually and ultimately disappear, even when the whole posterior cortex is quite opaque. The opacities commence to disappear at the same time from the equator and the posterior pole. It is considered the clearing up is due to the lens receiving its normal supply of nutrient fluid. This is supported by the fact that, if the naphthalinic lens is removed from the eye and placed in distilled water it regains its transparency in a few hours. This shows that a naphthalinic opacity is evidently the result of chemical changes in the nutrient fluid of the lens, and that the equatorial zones and the posterior pole play an important part in the flow of nutrient material to the lens. Similar results are obtained by replacing the blood in the vessels of a frog with a solution of sugar or salt when the lenses become opaque. If when this is obtained the frog is put back into water the lenses clear up once more. Also when a fresh transparent lens with uninjured capsule is placed in a solution of sugar or salt, the lens becomes clouded, owing to the fact that the solution absorbs the water from the lens very rapidly. If such a lens is put back in plain water, it again becomes transparent. Probably diabetic cataract, which usually attacks both eyes is of a similar nature especially as it is known that diabetic cataract sometimes disappears entirely if the health improves. Ergot, other drugs and certain plants are said to produce similar results to those of naphthalin.]

Total Cataract. General opacity of the lens is ordinarily fairly homogeneous at first. It is then an opalescent, silky, blue or slightly yellowish opacity still allowing the fundus oculi to be seen. Later, sclerosis of the nucleus, deposits of cholesterin in the form of plates which look like mica, or of chalky materials which punctuate the mass with yellow points,

render the opacity very heterogeneous and impermeable to rays of light. Sometimes the cataract is of a greyish or black colour. [It is often encountered in the horse and dog, more rarely in the cat and in tigers, and in other wild animals kept in confinement. It is also common in the canary, especially the crested or crest-bred variety. Gray has also observed it in wild birds at liberty. Fish in ponds are often affected with diffuse cataract.

General Smith observes that "opacities affecting the lens of the horse are not usually diffused, but circumscribed; about the size of pin points or pin heads are much more common than large ones, and it is in the detection of these that differences of opinion exist."

When the cortex liquefies whilst the nucleus remains hard after the lens has been opaque for some time it is termed a *Morgagnian cataract*].

Etiology of Cataract.

Complicated Cataract. This will be described first on account of its frequency in the horse, in which it is a complication of hæmorrhages of the iris and ciliary body, but particularly, and it may be said invariably of inflammation of these parts. It is met in all forms, the capsular most commonly. Total cataract fairly commonly follows abortive irido-cyclitis as well as the more serious inflammations of the uveal tract. It is so intimate and constant a part of affections of the uvea that it may be in some measure regarded as the sole symptom of this trouble, as may be gathered from the following example:

A horse attacked in one eye with irido-cyclitis with several recurrences closely following one another, suddenly showed a cortical cataract in the other eye, which developed progressively till in three weeks it had almost led to complete blindness. As a concomitant symptom a slight lessening of intraocular tension was noticed, the pupil became fixed in a condition of semi-dilatation following on a complete dilatation obtained at the commencement of the trouble with

atropine. There was no synechia. In the eye first attacked and affected for over a year, three attacks led to a slight punctated opacity of the capsule of the lens leaving the fundus oculi quite visible.

W. C. Spooner* has seen total cataract supervene within the tenth day of the first attack of irido-cyclitis in the horse. The preceding example shows that cataract may arise in all stages of this dangerous affection. Cataracts arising from disease of the structures of the eye or from injuries are termed *secondary* cataracts in contradistinction to *primary* cataracts arising from no appreciable cause.

Traumatic Cataract. This may be the result of a contusion, without perforation of the globe, or rupture of the capsule, but it is most often caused by an injury resulting in rupture or perforation. As a general rule it may be taken that "*any cause which opens the capsule produces a cataract.*" The opacity is the result of the layers of the lens being absorbed by the aqueous humour. The vitreous humour does not produce the same effect. From experiments by Schlösser it seems that wounds of the posterior lens-capsule do not cause cataract, or if they do the opacity remains limited. Traumatic cataract may be partial or total, partial if the wound in the capsule is narrow and does not allow the aqueous humour to enter, or only with difficulty, or if the superficial fibres swell and become herniated and so close the capsular wound. As a rule, however, the swollen and herniated fibres are themselves absorbed by the aqueous humour which thus continues its work of rendering the lens opaque; but it may also happen that a time arrives when the lens has become completely resorbed, and this is what is aimed at in the operation of discission.

Congenital Cataract. Certain forms such as posterior polar, lenticonus, and anterior polar cataract are sufficiently characteristic to be recognised in animals of any age. Besides these a cataract cannot be said to be congenital unless it is observed at birth. Under these conditions it has been

* *The Veterinarian*, 1840.

observed a good many times in the foal, dog and calf. It is generally soft and easily resorbed.

The causes to which polar cataracts can be attributed have already been mentioned. The other varieties are due to some abnormality in development, some intrauterine inflammation of the eye, or blows administered to the abdomen of the mother as Vueller has seen in the rabbit. Congenital cataract is often hereditary and then it is bilateral (Leclainche, Möller, Fromaget and Nicolas, Maleval). Gibson, in 1751, observed that horses were sometimes "foaled with cataracts or pearls in their eyes." Maleval has observed three cases of double lenticular cataract in dogs belonging to two litters; the mother, a black poodle, had normal eyes, but the father, of the same breed, an old rheumatic animal, showed a double cataract which had formed gradually.

[**Hereditary Cataract.** General Smith* says: "I regard the majority of cataracts in the horse as being hereditary, while the old-fashioned theory that an attack of ophthalmia is absolutely necessary as a prelude to the production of cataract, is probably nowhere now held to be true." Axe is of a similar opinion. The late Professor Pritchard, speaking (1900) of the rarity of cataract nowadays compared with former times, said it is due to the fact of not breeding from blind animals as formerly;† he absolutely thought the principal cause of cataract in the horse's eye is due to breeding from either a sire or a dam that has a cataract. This is commonly encountered in the crested and also the crest-bred canary; fanciers endeavour to eradicate it by refusing to breed from such affected birds. Experience has taught them that by this process of elimination their stock can be ridded of cataract. Cataract is more prevalent where in-breeding to fix the type is extensively carried out. The consensus of opinion among practitioners is that cataract is hereditary, and acting on this

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* Cataract in the Horse, by Veterinary-Captain F. Smith. *Journal of Comparative Pathology and Therapeutics*, Vol. ix, 1896, p. 136.

† Is it not due to the fact that periodic ophthalmia, the commonest cause of cataract in former days, is rare, if not unknown, in recent years?

view the Royal Commission on Horse Breeding schedule it as an hereditary disease of the horse.*

In the dog, especially in the poodle, there is an hereditary tendency towards cataract, this tendency increasing with advancing age. From the frequency of progressive cataract in the poodle it would be well to enquire into the antecedents of the attacked to see if there were a familial history of the disease. Gray has observed many examples of this. Similar cases have been observed in the pug].

Cataracts formed in consequence of General Diseases. *Diabetic cataract.* Haltenhoff, Fröhner, Schindelka, Sendrail and Lafon, Nicolas and numerous other observers have seen this form in dogs; but it is not a constant complication of diabetes mellitus. It is always bilateral and progresses fairly rapidly. Eisenmenger observed a dog which had 9.5 gm. of sugar per litre, saw the cataract disappear, then reappear in first one eye and afterwards in both with 17 grammes; finally the animal became blind from double cataract. [Not every cataract seen in diabetes is, however, a diabetic cataract].

The change in the composition of the liquid media of the eye determined by the hyperglycæmia is probably the cause of its development. Experiments on rabbits with naphthalin by Bouchard and Charrin go to support this pathogenesis.

Arthritic Cataracts (?). Two cases of cataract, one single the other double, observed by Mouquet in young dogs which had had several attacks of eczema on the nose, were attributed by this author to an arthritic diathesis. Maleval's case above mentioned falls under this heading.

Enzoötic Cataract. In eleven horses in stables 60 yards apart, Cuny† saw, in the same year, four horses affected with unilateral or bilateral cataract, and two years after a fifth horse was affected with the same disease. The cause was not determined.

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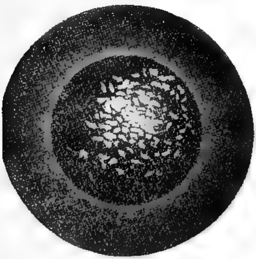
* E. Nettleship. On Heredity in the Various Forms in Cataract. *Reports of the Royal London Ophthalmic Hospital*, Vol. xvi, part iii, Nov., 1905.

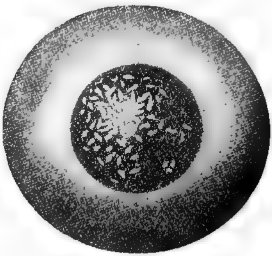
† *Journal de Med. Vet. et Zootechnie*, 1907.

Senile Cataract. This form, well known in man, in whom it is characterised by the slowness of its development, has not often been mentioned with regard to animals, perhaps because in some cases the true cause has not been recognised. However that may be, various authors have observed it in dogs and cats about ten years of age, Léclainche has seen it in very old cows, and as it is very rare in horses Hertwig attributes its rarity to the horse not living to a sufficient age for it to develop (?). Even birds are not exempt at about ten to fifteen years of age.

[**Parasitic Cataract.** This is not infrequent in fishes, especially in the perch and roach. It is usually set up by the



Cataractous Eye of Eel-pouch or Burbot (Lota lota) with larvæ of Diplostomum (Trematode) in Lens. (After Hofer).



Cataractous Eye of Rudd (Scardinius erythrophthalmus) with Diplostomum larvæ in Lens. (After Hofer).

larvæ of the Diplostomum volvens and Diplostomum annuligerum.* Myxosporidial and other protozoal parasites may also produce cataract in various fishes.

Spurious Cataract. This term is applied to those opacities or pigmentary spots or patches in the pupillary field not having connection with any disease of the lens.

The remains of the fœtal pupillary membrane, which give the pupil a greyish or whitish appearance, but which almost always is connected to the margin, and which is well shown up by the aid of atropine comes under this category. Such

* HOFER. Handbuch der Fischkrankheiten, 1905, p. 293.

remains are occasionally encountered in all our domesticated animals.

The adhesion or deposit of a portion of detached iris, corpora nigra, or uveal pigment on the anterior capsule of the lens is far from rare, especially in the horse, and forms another example. It is easily discriminated from cataract by its blackish or brownish colouration. It may, however, be associated with true opacity of the lens.

Strings or particles of coagula, due to inflammation of the uveal membranes may sometimes be found deposited on or adhering to the anterior lens-capsule, but their true nature is readily made out by the adoption of the various methods of illuminating the lens and by the history of the case.

The greyish or dullish lens of old animals can be differentiated from cataract by examination of the lens with the ophthalmoscope, when the whole area of the lens is found completely transparent.

Errors in Diagnosis. Numerous cases are on record in which the veterinary surgeon has been sued for damages for negligence in overlooking or failing to detect a cataract when present in a horse, generally a high-priced animal, at the time of purchase. In many instances the practitioner has been mulct in heavy damages and costs. Consequently it behoves the examiner to take every means in his power to obviate giving an absolute opinion on incomplete facts.

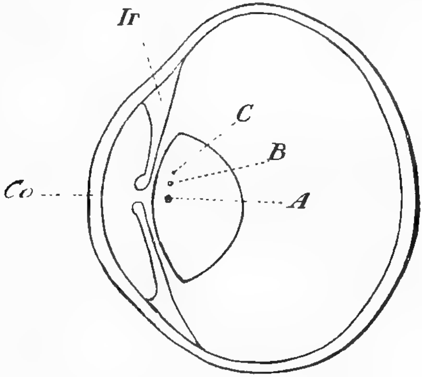
Errors of omission generally arise from the fact that the cataract has not been recognised because it was hidden behind the iris or corpora nigra when the pupil has been in a state of miosis. Even in the case where the pupil has fairly well been dilated a central opacity has been hidden behind the corpora nigra, more especially when unusually enlarged.

The schematic figure after Smith shown on page 369 will give one a clear idea of this.

Errors like these would be avoided if the examination were made when the pupil was fairly well dilated and the systematic use of the ophthalmoscope made. Even when very minute

opacities are centrally situated or in the field of a widely dilated pupil it may be impossible to detect them without an examination by the ophthalmoscopic mirror or by oblique illumination.

Too bright daylight or sunlight causes constriction of the pupil even when the horse is placed under an archway or doorway. Ordinary daylight transmitted by the ophthalmoscope to the eye in obscurity gives a fairly good view of the



A Vertical Full-sized Section through the eye of the horse. *Co* Cornea, *Ir* Iris.

"The pupil is shown contracted, but the corpora nigra are kept small and not allowed to touch, to prevent interference with the clearness of the diagram.

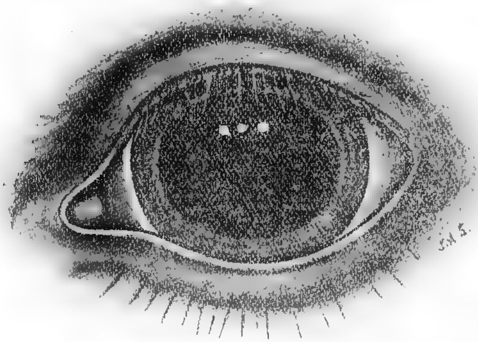
"If the pupil be contracted, a cataract in the position A could only be seen if situated to the *right* or *left* of the centre of the lens, but neither cataracts B nor C could be seen.

"Cataract B could be seen with a somewhat larger pupil, especially if situated to the right or left of the centre of the lens.

If the pupil be moderately dilated, cataract C can readily be detected." (Smith).

lens, and its transparency. Artificial light, as that of a candle or oil, gas or electric lamp, transmitted by the ophthalmoscope to the horse's eye in obscurity enables one to get a wider view of the lens than even by transmitted daylight.

Errors are liable to be made in the opposite direction; that is, stating a cataract is present when there is, in reality, no cataract. Such errors are often made by mistaking the reflection of some outside object, as the reflection of the mirror or its sight-hole, the image of one's face or of some article of clothing as the collar, etc., on the lens. Again, strings or specks of mucus on the corneal surface, corneal opacities, minute coagula in the anterior chamber, detachment of a corpus nigrum or adhesion of a small portion of the uveal pigment to the anterior face of the lens-capsule, etc., are all liable to be mistaken, by the student, for cataract.



Atropinized Eye of Horse, showing three small opacities that would have been hidden by the iris if atropine had not been used.

Another error is liable to be made: in mistaking the dullish greyish appearance of the lens of aged dogs and cats and sometimes of aged horses for cataract. If such pupillary reflections are examined with the ophthalmoscope, the lens is found to be transparent, and the background of the eye is seen without any haziness. This greyness of the pupil is due to the fact that as age advances the lens gradually becomes harder so that its refractile power decreases; its surface reflects more light and its substance becomes rather fluorescent.

Prognosis of Cataract. Although opacities in the lens never clear up, unless in very rare instances, they either increase in area or remain stationary. In the majority of partial opacities, in the form of dots, which may vary in number, and of hereditary or congenital origin there is, in the case of the horse, no inclination to progress or invade the whole area of the lens. As a rule opacities that appear for the first time during adult or middle life, as in the dog, advance very rapidly, generally first in one eye and then in the other, until the lens becomes totally invaded.

Opacities of the lens complicating disease of other structures of the eye generally progress rapidly until the whole substance of the lens becomes opaque. The small dot-like or nebulous opacities in the centre or periphery of the lens do not, in the horse, appear to interfere with the normal acuteness of vision.

The mere presence of a cataract may not interfere with the working capabilities of an animal, but there is always a possibility of it progressing until the sight is lost. Congenital, hereditary, primary, or spontaneous cataract, that is, one not arising from a disease of some other structure of the eye renders an animal useless for breeding purposes; at least, an animal so affected should not be bred from.

Total cataract, or a cataract progressing so as to destroy or give an imperfect vision lowers the value of a horse for certain kinds of work; or in the case of the saddle-horse renders him dangerous if not valueless for riding. In the case of a partial opacity in the form of one or more nebulous spots showing no tendency to progress or involve the whole substance of the lens the purchaser, should he have no objection to take the animal on account of the mere presence of the nebulous opacity, should have the future acuteness of vision guaranteed].

Treatment of Cataract. In spite of attempts at treatment by medical means, and the pretended success obtained by different drugs, especially phosphorus, cataract only yields to

surgical intervention. [Dr. Louis Dor,* of Lyons, asserts, however, that a cure of incipient cataract in man with an iodine salt, as recommended by Badal, is possible. He based his investigations on the well-established idea that cataract is produced by a ferment which passes into the aqueous humour, whereas it ought to remain in the blood. The ferment, which is a hydrating one, determines the hydration of the albumins of the lens. With a view to the destruction of this ferment, Dor experimented with many drugs and combinations, and has proposed the following as the best:—

Dessicated sodium iodide	5	grammes.
Crystallised calcium chloride	5	,,
Distilled water	400	,,

He says "With this solution one can check the progress at least eight cataracts out of ten, can cure one, and can expect failure in the tenth." It is used in the form of an eye bath and should be continued over a long period, dropped and then recommenced. The salt used by Badal was iodide of potassium].

The different methods of surgical intervention employed in human practice have all been used in dealing with animals (discission, reclination [or "couching," depression or displacement], and extraction) and it must be admitted that all who have attempted these operations are unanimous in stating that the conditions are in every way less favourable to success than in man.

Anatomical conditions. The relative narrowness of the supero-inferior diameter of the orbit in the horse, the consequent small size of the palpebral opening encompassing the cornea and hindering the manipulation of instruments; still more important, in the dog as well as in the horse, is the power of retracting the choanoid muscle which draws the eyeball to the depth of the orbit, causing the membrana nictitans to be protruded across the eye and necessitating complete narcosis to control the muscles, are, as a rule, difficulties which always render the surgeon's task very arduous (Berlin, Haltenhoff, Valude).

* La Clinique Ophtalmologie, 10 Janvier, 1911.

The relative size of the lens of the horse, and especially of the dog, diminishes the chances of success with the method of extraction. The corneal or scleral incision has to be of such a size to allow the extraction of the lens that to repair it such considerable reactionary phenomena are necessary that a widespread infiltration of the cornea is caused, and resorption is slow and often incomplete (Peters, Haltenhoff, and Nicolas). Further, the eye is more exposed to risks of infection. Chas. Bell Taylor, however, did not experience any difficulty, and did not take any special precautions after the operation.

Frequently, extensive hæmorrhages of the iris render the success of the operation more uncertain (Valude).

Conditions relating to Cataract. In the dog, in which cataract is congenital, traumatic, diabetic, or senile, intervention is often indicated. The reverse is the case in the horse, in which cataract is especially complicated by and is always the result of inflammations of the uvea. [Axe's experience, however, does not agree with this statement, for he has several times seen cataract appear without obvious cause or previous inflammation].

Operating for cataract is in no way indicated, since its object is to allow luminous rays to reach the retina, which after inflammation of the uvea is always more or less seriously affected; the only object would be to improve the appearance.

Conditions governing the method of operating. Lastly, in the best of cases the indications for one or other method of operation are very limited. Extraction in the horse is almost invariably followed by atrophy of the eyeball, as has been proved by different attempts made by Peters, Lorenzon, Wiart, Rolland, and Nicolas.

Reclination [or couching] which consists in pressing the lens back into the vitreous humour, no matter what form the cataract may take, offers chances of success which have not yet been determined. [This operation was well known to Bracken and Gibson in the middle of the 18th Century, and

has been adopted in human surgery for more than a thousand years]. Comparatively easy to perform, the following complications are to be feared. Wassilieff and Andogsky experimenting on rabbits have, in twenty-four operations had the following results: detachment of the retina in 19 cases, irido-cyclitis in six, and obliteration of the angle between the iris and cornea in six cases. Valude had no success in dogs owing to blood getting into the vitreous humour. Wiart experienced a difficulty in practising depression in the horse on account of the existence of synechiæ.

However, Berlin in the dog, and Bayer in horses, have performed the operation with success. Möller believed that it should be recommended in cases in which the cataract had no chance of being resorbed after discission, and Bayer in those in which an improvement in appearance only was desired.*

Discission, the principle of which depends on the fact already mentioned, that traumatic cataracts are absorbed by contact with the aqueous humour, has the advantage of being simple, and of exposing the eye to infection as little as possible; unfortunately, it is necessary that the cataract be a soft one, and it is therefore not applicable in every case. Nevertheless it is the method which has given the best results in the dog in the hands of Berlin and Möller, and Randolph, who have operated in a good many cases. On the contrary, Lanzilloti-Buonsanti, Röder, and Bayer have had no success in the horse.

The functional value of the Eye after the operation. An animal deprived of its lens is inferior from the point of view of vision, but it has recovered the power of perceiving light to an appreciable extent. It is not even without some power of distinguishing objects, as can be believed from the fact

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* For Leblanc, Beauclerc and Gohier's experience of this and other operations for cataract, *vide* Percivall's Hippopathology, Vol. iii, 1858, p. 124.

that light and shade can be made out and the animal can follow its master.*

[Chas. Bell Taylor † considers extraction of uncomplicated cataract in the horse is preferable to blindness. He attempts to contravert that a horse deprived of his lens would be dangerous and that spectacles would be necessary to compensate for the loss of the lens. He says, "Infants, for instance, in whom the lens has been removed cannot wear spectacles, and yet recover excellent sight for all ordinary purposes. This is the case even later in life; indeed, I have known a surgeon able to operate without glasses after undergoing the operation of extraction for cataract."

Randolph,‡ who reported an account of removal of both cataractous lenses in a dog, also states that it is not necessary to compensate their loss by the use of spectacles; he mentions cases of reproduction of the lens in perfect form after extraction in the dog, cat and rabbit.]

Randolph has stated that a dog operated on by him was able to be used for hunting, and Suarez de Mendoza suggests calling in the assistance of ophthalmologists by reporting that after the extraction of a double cataract in a dog he persuaded the animal to wear correcting glasses encased in a metal frame into which the dog, after a few days, came to put his head of his own free will.

Berlin, who has had a great deal of experience of the operation for cataract in the dog, is less optimistic. Although considering the operation perfectly justified, he does not believe that the animal regains his sight sufficiently to be useful for special purposes such as sheep dogs and sporting dogs are required for. On the other hand, he considers that correcting glasses cannot properly be measured as to their power

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* "The power of vision in man operated on for cataract," says Fuchs "is, without spectacles, just sufficient to allow of their walking by themselves or performing rough work."

† *Veterinarian*, 1873, p. 669.

‡ *John Hopkins' University Hospital Bulletin*, Feb. 1895.

and cannot conveniently be fixed, and are more harmful than useful.

Operation for Cataract. The object of the preceding observations has been to lead surgeons to be able to determine the conditions under which intervention in animals is allowable, and to fix in each case the most practicable method. Sufficient data have not yet been collected to allow of a definite choice being made, and the technique of discission, reclination and extraction will briefly be given.

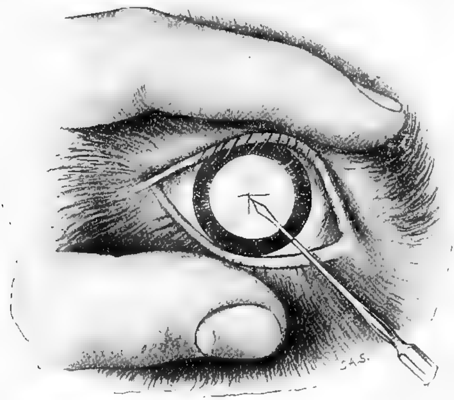
Discission. This operation, commonly termed needling, consists in lacerating the anterior capsule of the lens in order to allow the aqueous humour to come in contact with the substance of the lens.

Instruments. A spring eye speculum, fixation forceps and a discission needle.

Fig. 124. Discission Needle.

Preparation of the Eye and of the Animal. The pupil is dilated by instillations of atropine made the previous day. General anæsthesia is recommended by Möller: morphia in the dog (15 centigrammes injected subcutaneously half an hour before operating, and then inhalations of æther to cause muscular relaxation); chloroform in the horse. [Most British practitioners, however, prefer chloroform after morphinization for the dog. French veterinary surgeons use a preliminary injection composed of morphine hydrochloride 10 centigrammes; atropine sulphate, 5 milligrammes; distilled water, 10 grammes. Of this mixture from 1 to 4 cc., is, according to size of dog, injected 15 to 30 minutes before chloroform anæsthetization]. Berlin operates after a simple local anæsthesia by means of a 10 per cent. solution of cocaine. The eye speculum may still be used, but Berlin dispenses with this and uses the fingers of the left hand to separate the eyelids.

Operation. The eyeball and conjunctival culs-de-sac having been irrigated with a warm antiseptic solution, take the discission needle in the fingers like a pen and at a point at the periphery of the cornea 2–3 mm. from its margin, in the most convenient situation for the operator, usually the external angle of the eye, pass the needle into the anterior chamber, in front of the iris, taking care not to injure this membrane. By directing the point towards the lens and by making slight movements, tear a small area of the anterior capsule. Too strong pressure may luxate the lens.



Berlin's method of performing Discission in the Dog.

The needle is withdrawn and the eye left without any dressing. The puncture made by the needle being very slight little aqueous humour escapes and the eye does not run much chance of becoming infected; but to avoid any chance of an accident of this nature a little yellow oxide of mercury ointment should be placed between the lids and the animal prevented from rubbing the eye. After 48 hours all danger of infection is over.

The resorption of the lens is sometimes complete after the first month or six weeks, but it may take two or three. When it is not complete a second operation may be performed.

Complications. Swelling of portions of the lenticular substance may, in man, cause attacks of glaucoma, but this has not been observed in the dog (Möller); or symptoms of iritis may be shown, but this may be prevented by continued instillations of atropine.

Discission is especially successful in young animals in which the lens is not sclerosed. It is indicated in cases in which the cataract is not complete—not mature.

Displacement or Couching. This operation consists in luxating the lens after having opened the capsule, or without

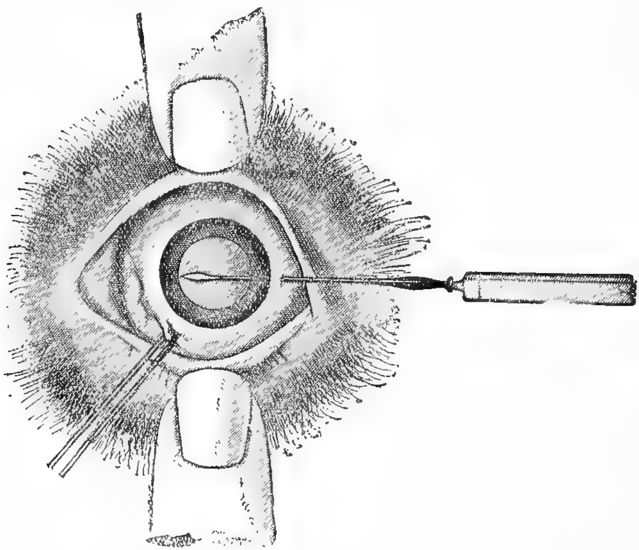


Fig. 125. *Displacement* or "couching" of the lens in the dog (Cadiot and Almy). The discission needle is here passed through the sclerotic into the posterior chamber between the iris and the lens.

doing this. (Figs 126 and 127). First of all dilate the pupil with atropine and place the eye speculum in position. Seize the eyeball with fixation forceps. With the discission needle puncture the sclerotic a few millimetres from the margin of the cornea and a little below the horizontal diameter, in order

to avoid wounding the ciliary body and the long ciliary artery; then pass in the instrument in such a way that it enters between the anterior face of the lens and the iris and appears in the field of the pupil. By pivoting the needle at the scleral opening the lens is pressed from above downwards (depression) or from before backwards (reclination) to luxate it into the vitreous humour. [According to Professor Macqueen, in forward or anterior couching the lens is displaced into the anterior chamber; and in backward or posterior

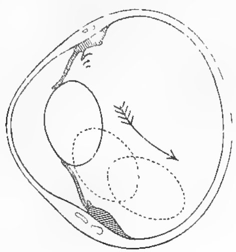


Fig. 126.
Depression of the lens.
(Dog).

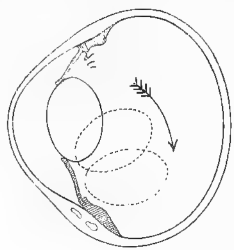


Fig. 127.
Reclination of lens.
(Dog).

couching or reclination, the lens is displaced into the posterior chamber towards, but not into, the vitreous humour]. This being done the lens is kept in this position for a few moments in order that it does not spring back, and the needle is withdrawn.

Extraction. The instruments required are: An eye speculum, fixation forceps, von Graefe's knife, a cystitome, and a curette, another pair of forceps and a pair of iridectomy scissors. The instruments used in man will be suitable for the dog. The size of the eye in the horse requires the use of an eye speculum and a von Graefe's knife about double the the usual size.

A general anæsthetic should be administered, though Nicolas was able in one case to operate on a horse with cocaine only.

The Incision in the Cornea. In the dog the incision may be made above. In the horse the orbital rim does not allow the eye to be sufficiently exposed in this region and the supero-external region is chosen. The incision should be made in the sclero-corneal limbus, and should be a little less than a half the circumference of the cornea in the dog, and about one third in the horse. Place the eye speculum in position. Cleanse the site of operation and the culs-de-sac of the conjunctiva with a warm solution of one of the antiseptics already mentioned.


Fig. 120. Cystitome.


Fig. 129. Curette.

With the fixation forceps, held in one hand, seize the conjunctiva near its junction with the cornea, at a point directly opposite to the spot chosen for the incision. With the other hand puncture the cornea with the knife, and pass it through the anterior chamber to a point which is to be the other end of the incision, and here make another puncture, keeping the knife parallel to the iris all the while it is in the anterior chamber. By upward sawing movements make a cut in the cornea so that the incision is always in the junction of the two membranes.

Remove a large piece of the iris (iridectomy) and then remove the fixation forceps and the eye speculum.

By means of the cystitome introduced through the wound, make a large cross-shaped tear in the anterior capsule.

Extract the lens by pressing on the front of the cornea with the fingers.

[Borthen, Bergen, Norway, in a foal extracted the congenital opaque lens of one eye by the lower incision flap; the lens was split, and the posterior lens-capsule was cut through. In the second eye the posterior lens-capsule was

not cut through. The eyes were not bandaged. Some months later the eye in which the posterior lens-capsule was cut through did not show any opacity, while the other eye

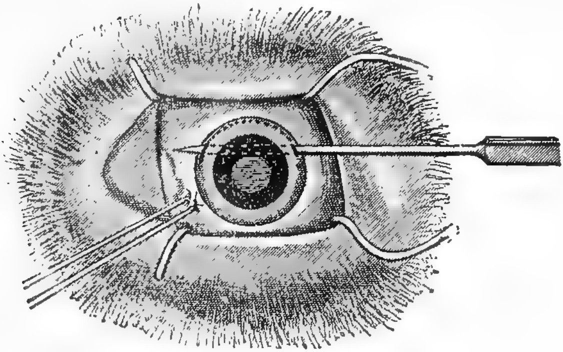


Fig. 130. Extraction of a cataract in the dog (Cadiot and Almy). Incision of the cornea.

showed some of the remains of the lens in the papillary region].

Dressing. Make sure that the edges of the incision in the cornea are well coapted, without including any of the iris, and

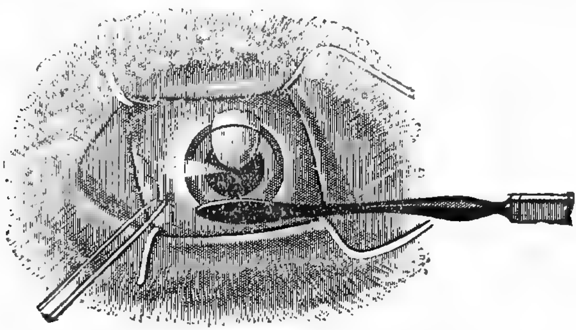


Fig. 131. Exit of the cataract (Cadiot and Almy).

apply a dressing, according to the case, as described on p. 108. Suarez de Mendoza sutured the corneal wound and obtained healing in a week. [Chas. Bell Tayler did not

adopt any after-dressing, but merely confined the animal in a dark box].

Complications to be feared are the escape of the vitreous humour—it should be cut on a level with the incision; hæmorrhages, and luxation of the lens; in the last case the lens must be sought for with a hook, as has been done by Harrison on a dog.

(For the *Medico-legal aspect of Cataract vide* the article on Cataract in Percivall's Hippopathology, Vol. iii., and the case Lord Randolph Churchill *versus* Day, *Veterinarian*, 1871, p. 626).

Defects of homogeniety in the lens. This condition is not rarely observed in the horse and dog, and may lead to a wrong diagnosis as to the presence of an opacity. It can be recognised by the direct method at 25–30 mm., or by skiascopic examination at a metre or more, by the existence of a grey nucleus or of concentric circles of the same colour separating the clear parts; the path of the skiascopic shadows is paradoxical or abnormal (*See* p. 77). By the upright image every opacity disappears, but the fundus oculi is not equally clear at all parts and varies with each movement of the observer, because the lens differs as to its refractive power very considerably from one zone to another.

In a dog which, by the naked eye, showed a cloudy nucleus, and by direct illumination a markedly grey nucleus, and in which a cataract had been diagnosed, there was in reality a nuclear myopia of 5 D.

A heterogeneous condition of the layers of the lens is most often congenital but may be pathological. It is seen after some cases of irido-cyclitis in the horse.

In man it has been noticed that cataract is often preceded by myopia, which especially attracts the attention of the ophthalmologist, as it usually appears at an age when presbyopia is to be expected. It is probable that in our animals, particularly in the dog, the same relationship could be established between an increase of density of the nucleus of the lens and the consequent development of cataract.

Displacements of the Lens. The lens being fixed in place by the fibres of the zonula of Zinn, any alteration in these fibres tends to displace it.

Rupture of the Zonula of Zinn or Zonulodialysis. Tearing of the zonula of Zinn, even if slight in extent, is easy to diagnose in the horse, in which it is fairly common, though the lens may keep its normal position. A description of cases seen in man by Phisalix contains some of the following symptoms: Before the instillation of atropine, a notch, which is the outward sign of the retraction of the ciliary body and iris, on a level with the rupture of the zonula, is seen at the edge of the pupil. This having attracted attention, dilate the pupil to indicate exactly the position of the rupture. In a state of complete dilatation and by the direct method of illumination it is possible to see under the edge of the pupil, and in the region corresponding to the notch above mentioned, a zone which reflects light more than normally. If an attempt be made to examine into this phenomenon by directing the rays from the ophthalmoscope obliquely in order to throw them on to the part which attracts attention, a very brightly illuminated crescent appears, the central border of which is formed by the equator of the lens, and the excentric border by the ciliary body. In this crescent may be found traces of the zonular tract in the form of black points on the lens, with the stretched fibres joined to the crescent near its extremities, or ruptured and floating about. The crescent measures in its length the extent of the tear in the zonula, and in its thickness the degree of retraction of the ciliary zone. Its special luminosity is doubtless due to the rays reflected by the fundus oculi not undergoing the same refraction in traversing it as do those which pass through the lens.

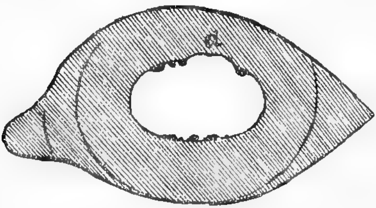


Fig. 132. Notch *(a)* in the edge of the pupil denoting a tear in the zonula (horse)

Glancing at Fig. 133 it can be seen that the iris being drawn out excentrically clearly shows, when the eye is completely dilated, a larger field, which consequently allows the equatorial region of the lens to be seen—it is invisible under normal conditions. A symptom pointed out by Phisalix in man is the *difference in refraction between the parts of the lens bordering on the rupture and those more remote from it*, the former being myopic and the latter being emmetropic; this proves that the lens not being drawn outwards by the zonula has its curvatures increased.

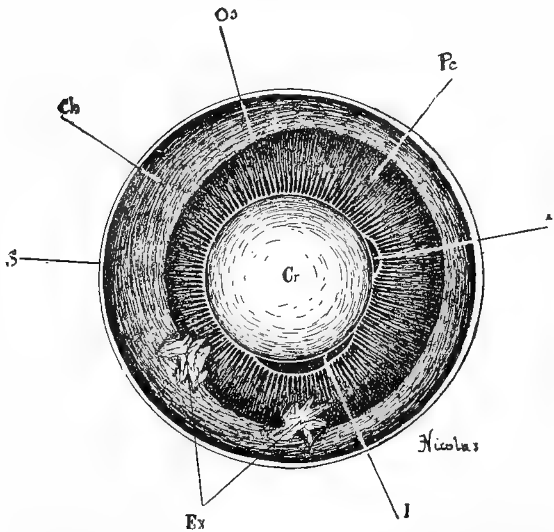


Fig. 133. Anterior segment of the eye of a horse, seen from its internal face, showing two ruptures in the zonula (*I*, *I*), and precipitated or coagulated exudates (*ex*) on the surface of the ciliary processes.

In the horse, in which animal Nicolas has several times seen zonulodialysis, in one case almost extending to one-fourth of the circumference of the zonula, this fact has not been clearly proved, though Nicolas has carefully examined all the cases with which he has met.

This alteration may be determined by a *contusion*, as in the case reported by Phisalix. *In the horse zonulodialysis is especially a complication of ciliary affections.*

In one case Nicolas was able to confirm a clinical diagnosis by an anatomical examination (*See* Fig. 133). In this example, besides two ruptures in the zonula, there were two star-like masses of organised fibrous exudate at the edge of the processes, one of which must have played a mechanical part in the rupture of the zonula.

In the production of this alteration there may be some reason also to incriminate inflammation in general which, by the malnutrition which it causes in the eye, leads to a more or less marked atrophy of the ligament of the lens.

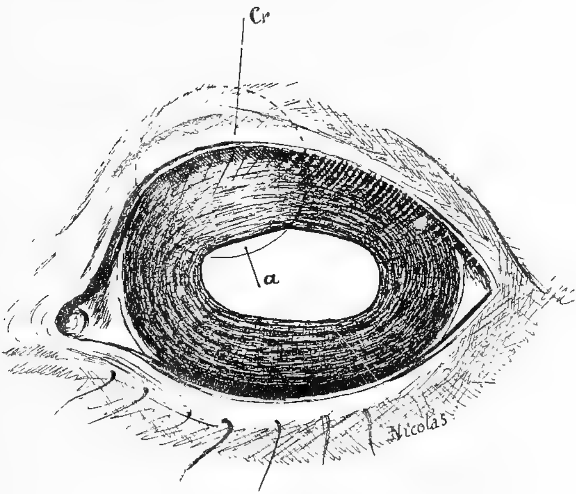


Fig. 134. Upward luxation of the lens in a horse.
(*a*) Segment of the lens visible in the pupil.

This lesion is *relatively serious* in proportion as it prepares for luxation of the lens.

Subluxation and Luxation of the Lens. Every time the lens loses its relationship, with regard to position, with the optical axis of the eye there is some displacement of the lens.

If the displacement is slight it is spoken of as *subluxation*; if on the other hand the lens has completely lost its normal position there is *luxation*.

Subluxation. This displacement may be made either around one of the axes of the lens or more or less in the plane of its equator.

Deformity of the iris and of the pupil is almost invariably the rule. The iris is pushed forward by one part of the margin of the lens or even by the thickest part of the lens, as is shown in Fig. 134; the border of the pupil presents a notch, a projection, or sometimes a rectilinear profile, determined by the tension of the iridic membrane. In other regions the iris is subject to undulating movements produced at each movement of the eye or of the head, called *trembling of the iris* or *iridodonesis*. Sometimes its anterior face, in parts which are no longer held by the lens, presents a plane, uniformly coloured surface on which the concentric circles seen on a normal membrane are no longer visible; the iris is then said to be unfolded (déplissé).

With the ophthalmoscope the pupil is unevenly illuminated. It is usually crossed by a thin curved line (showing where the lens has stopped) which divides it into two regions each giving a different image of the fundus oculi, allowing that the lens is still transparent; one of the images is normal in size, the other is considerably shrunken, and this is furnished by the aphakic region, or place where the lens is not in contact with the zonula of Zinn. If the lens is affected with cataract this obstructs a part of the field of the pupil.

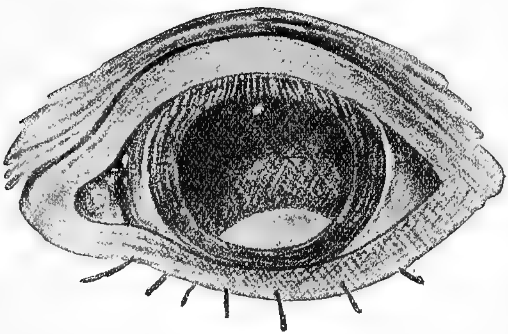
Luxation. This may take place into the *anterior chamber* or into the *vitreous humour.*

In the anterior chamber the diagnosis can be made at a distance. [At times one may see the floating lens in the anterior chamber, but at other times it may be lost to view, having passed through the dilated pupil into the posterior chamber: it is hidden behind the iris].

In the vitreous humour the objective symptoms are the trembling, and the flat or unfolded appearance of the iris and

the reduced size of the image of the fundus oculi, which is due to a high degree of hypermetropia resulting from the absence of the lens.

A good idea of the reduced size of this image can be obtained by practising illumination of the fundus oculi by the direct image on a normal eye, using successively the six negative lenses of Badal's ophthalmoscope. In proportion as the power of the glasses is increased, the image decreases. The reduced image resulting from aphakia in the horse is much smaller, since the hypermetropia may measure about 13 D.



Fig, 135. Luxation of the lens into the vitreous humour (eye of horse).

Lastly, the luxation of the lens can be made certain by looking for the displaced body in the deeper parts of the vitreous humour, or by noting the presence or absence of the images of Purkinje-Sanson (*See* p. 45). In the vitreous humour the lens usually appears as a sphere or crescent, opalescent or greyish in colour. Its size is apparently larger than that of a normal lens, in consequence of its increased magnification by the cornea.

Subjective symptoms drawn from comparative ophthalmology consist in *monocular diplopia* if the lens has remained transparent and is partly in the field of the pupil, the rays which pass through the lens and those which go directly to the

retina giving different images; if the luxation is total, vision is reduced to that of a subject operated on for cataractous lens, *i.e.*, in cases in which the lens has not been luxated into the anterior chamber. Besides these defects of vision, the eye affected with this displacement of the lens is exposed to complications, which have been mentioned on p. 374.

Etiology. Luxation is congenital or acquired. In the first case it is due to defective development and is coincident with other malformations, or it is due to causes ensuing during fœtal life. If acquired, luxations are complications of uveitis, especially in the horse (18 times out of 19 cases according to Schindelka), buphthalmos, or traumatisms (Steullet, Schindelka). Very frequently observed in the horse, it has also been recorded as occurring in the dog, cat, or ox. [Nunn* reported a few cases in the horse.

Floating lens causes a posterior keratitis with at first an opacity at the inferior two-thirds of cornea. As time goes on the opacity increases in density, as well as in area, until the whole cornea becomes permanently opaque. Not rarely one eye, sometimes both eyes undergo chronic panophthalmitis with hydrophthalmos. In the figure of dog's eyes on p. 401 several years elapsed before hydrophthalmos of the left eye manifested itself. At the earlier period after the luxation of the lenses the animal could see better at night time than during daylight].

Treatment. In complete luxation extraction of the lens is indicated only if it is situated in the anterior chamber or if it gives rise to sympathetic symptoms in the vitreous humour. A hook or tractor should be made use of (Harrison). It may in some cases be advisable to transform a subluxation into a complete one. [In certain cases discission may be all that is necessary].

Congenital Anomalies. *Ectopia of the Lens.* The lens is displaced and the clinical appearance is that of a subluxation with this marked difference, that the aphakic pupillary

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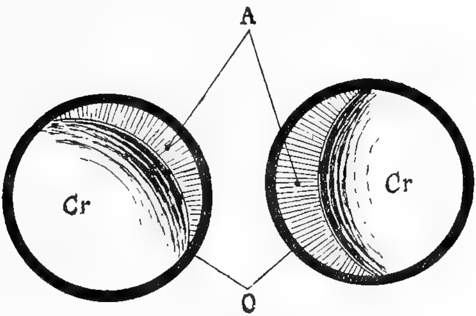
* *Veterinary Journal*, 1886.

crescent is traversed by the fibres of the suspensory ligament, which are elongated but intact.

Nicolas has seen three cases of this anomaly in the horse; in one it was bilateral. The displacement of the lens measured by the arch of the aphakic crescent between the margin of the lens and the pupil, varied from 3 to 5 mm. The lenses were absolutely transparent and sight was normal.



Congenital ectopia of the Lens of Horse.

A, Aphakic crescents, crossed by the tract of the zonula of Zinn.
Cr, *Cr*, Lens in a position of ectopia.
O, Pupillary fields dilated by atropine.

CHAPTER X.

THE VITREOUS HUMOUR.

Anatomy.

The vitreous humour is a transparent, colourless, jelly-like mass, sufficiently firm in its normal condition to allow it to be cut, occupying the space between the posterior face of the lens and the retina. It has the form of a spheroid, with a cup-like depression in its anterior part (*fossa patellaris*) to receive the lens.

Anatomically it is made up of an enveloping membrane and the vitreous humour itself. The enveloping or hyaloid membrane covers the internal face of the retina; it is itself covered on its vitreous face by a layer of flat cells; in front on a level with the ciliary processes it is thickened and gives rise to the fibres of the *zonula of Zinn* which constitutes the suspensory ligament of the lens.

The vitreous humour is composed of an amorphous substance and of small embryonic cells, the whole being contained in a transparent mesh of loose tissue which forms a framework. It is traversed from behind forwards by a canal going from the papilla to the posterior pole of the lens; this is the hyaloid canal or the canal of Cloquet, which in the fœtus gives passage to the hyaloid artery. It disappears at birth, but the canal itself persists in the adult though it is not visible. After the disappearance of the hyaloid artery the nutrition of the vitreous humour is dependent upon the uvea. When a fresh eye is opened the vitreous humour comes forward from the posterior hemisphere, dragging with it the retina, but it remains adherent to the ciliary processes and to the posterior face of the lens. [In the ox, the vitreous humour is less fluid than in the horse].

Hyalitis. If a septic foreign body gains access to the vitreous humour there is a reaction. Experiments by Haen-

sell on the dog, cat and rabbit have shown that around a thread of cotton or a pellet of lead which he introduced, during the first hour was formed a slight haziness which enveloped the foreign body like a cocoon, and became insensibly lost in the surrounding vitreous. This haziness may be localised and resorbed, but it may progress and extend forming an opacity; the inflammation then invades the retina and the uveal tract.

Experiments have also shown that the introduction of oxidizable aseptic foreign bodies, such as mercury, copper, nitrate of silver, or oil of turpentine, cause suppuration in the vitreous humour.

Hæmorrhage into the Vitreous Body. As a primary condition this is rare. Tsarenko, Blazekovic, and Möller, have reported on them in the horse following on blows or falls; Kohner has also seen them in dogs. If they are extensive the fundus cannot be illuminated.

On the other hand, they are frequent in irido-cyclitis in the horse; but they are never produced until the anterior media have become opaque; in these affections they have consequently only a anatomo-pathological interest.

Prognosis is serious, the presence of a large quantity of blood in the vitreous humour resulting in the disorganisation of the eye, as has been shown by the experiments of Pröbsting in the rabbit, described elsewhere (*See* p. 326).

Opacities of the Vitreous. As has been said, these may result from the introduction of a *foreign body;* they most often denote *inflammation of the uveal tract* or of the retina; lastly, they may be *congenital remains* either of the framework of the vitreous humour or of the vascular membrane of the lens, or of the hyaloid artery or hyaloid canal. These opacities are met with in 10–15 per cent. of horses (Schmidt). Viewed with an ophthalmoscope these opacities may take the form of "dust-like" specks, filaments or membranes.

Dust-like Opacities. These give the vitreous humour the appearance of mare's urine (urine jumenteuse), and the fundus

oculi, a dirty yellow tint which makes the different regions appear as a uniform blurred image. If they invade the whole of the vitreous humour they are produced by a generalised uveitis; localised towards the front, behind the lens, they are symptomatic of inflammation of the ciliary body; whilst in the layers bordering on the retina they denote retinitis or, more certainly choroiditis.

Filaments. Often *inflammatory* in origin, sometimes *hæmorrhagic*, they are most likely to be met with in the anterior regions of the vitreous because they come from the ciliary body. They are then clearly visible with an ophthalmoscope.

In other cases, more particularly *when they are congenital* they are so fine or so diaphanous that they may easily pass unperceived, unless the observer has had a great deal of practice in the use of the ophthalmoscope. In their "Précis d'Ophtalmoscopie Vétérinaire," Nicolas and Fromaget have described the following special method to be used when examining an eye for these opacities: Using day-light it is sufficient "to illuminate the media, as usual, with the ophthalmoscope, but to look into the eye from the side of the mirror and not through the hole in its centre." Recently Schmidt has recommended the use of lateral illumination by means of Priestley Smith's lamp. When they reflect the daylight these filaments appear whitish, like porcelain. They are found in the anterior segment of the eye, probably because this is the only region which can easily be illuminated by the method of lateral illumination. There the filaments form a fine framework, even simulating the framework of the vitreous humour. At other times their attachment to the periphery of the lens, their radiating direction towards a point on the lenticulo-papillary axis, their disposition in the form of a funnel, indicate sufficiently clearly that they are the remains of the capsule of the lens or of the hyaloid cord (Fig. 122).

Membranes. Variable in colour, number, and extent, and also in thickness, the membranes of the vitreous humour sometimes have a form which indicates their origin. In a

four year old horse one of these membranes, in the form of a pigmented crown resembling a thick spider's web, could be seen floating in the vitreous humour behind the lens, and it was adherent in one point to the superior region of the ciliary body, from which it was certainly derived.

They may represent fibrinous or already coagulated exudates or remains of blood clots. When situated in the deep regions they may give the idea that there is a proliferation of the retina, and in man they are described under the name of *retinitis proliferans*.

Diagnosis. The diagnosis of opacities, even of the finest, is comparatively easy when the precautions indicated with regard to illumination are taken. Their causal origin is sometimes very much more difficult to determine; it may be discovered by a complete examination of the eye. First considering inflammation of the uveal tract; there is, in this case, a diminution in the volume of the eye, hypotension, the iris is adherent, or does not dilate completely under the influence of atropine, the lens is more or less opaque, etc.; they are capable of being resorbed. If the opacities are congenital in origin the eye will be otherwise healthy, but will probably show other congenital remains such as posterior polar cataract, lenticonus, a visible hyaloid artery, etc.: the disappearance of these cannot be counted on with certainty.

Prognosis. Their seriousness first of all depends on the obstruction which they cause to vision; from this point of view their number, thickness, and the fact of their more or less completely invading the vitreous humour should be taken into consideration. It must be admitted that the retina does not receive more luminous rays than it sends to the eye of the observer. Besides this the movements of these bodies may render the animals irritable, nervous and difficult, etc. Lastly, the prognosis is more serious if there is any sign of previous uveitis as it may be recurrent. The fine or diaphanous congenital opacities seem to be of little importance.

Treatment. If it is believed advisable to interfere, this

should take the form of administrations of purgatives, diuretics and potassium iodide.

Synchisis. This is the name given to liquefaction of the vitreous humour which is always the result of some alteration.

In a normal eye the consistence of the vitreous humour is such that it will not allow a body to move through its substance, following the movements of the eye. However, in perfectly normal eyes showing a hyaloid artery it may be seen moving from one side to the other like a lightly stretched cord in a wind. This seems to show the presence of a hyaloid canal, the diameter of which must be considerable.

Liquefaction of the vitreous humour is constantly accompanied by the formation of opacities, and it is the rapid movements of these opacities which allows a diagnosis of synchisis to be made. [Such opacities in the vitreous move like solid particles or minute strings move in a bottle just after it has been shaken. The rapidity or slowness with which they move depend very much on the consistence of the fluid. If the opacities move very slowly one may conclude that the vitreous humour is probably normal in consistence]. Contrary to what might be expected, hypotension is not a sign of softening but only a symptom of diminution of the volume of the contents of the eye.

Synchisis scintillans. In this form of softening, the opacities are brilliant and resemble metallic spangles thrown into the vitreous at each movement of the eye. These "spangles" formed of cholesterin or tyrosin crystals are fairly frequently met with post-mortem in horses which have been the subjects of irido-cyclitis (Sichel, Jacobi, Möller, Nicolas, and Schlampp). Synchisis scintillans is much more rarely observed clinically; Berlin has only reported two observations, one in a horse in which white or clear yellow spangles filled the whole of the vitreous and gave the fundus oculi the appearance of the sky on a clear starry night. His other case was in a pigeon. [It is, however, not rare in the dog, in which sight does not seem to be abolished. Gray saw a case in an old pug, which had also in one eye a long filamentary anterior synechia. In

this case the "spangles" could easily be seen by the naked eye].

Experimentally Panas has induced this form in a rabbit by giving it naphthalin. The shining bodies were entirely formed of crystals of sulphate and carbonate of lime, with no trace of cholesterin or tyrosin.

Congenital Anomalies.

Persistence of the Hyaloid Artery and of the Hyaloid Canal or the Canal of Cloquet. These vestiges of fœtal vascularity of the lens and of the vitreous humour are fairly frequently met with in the horse. Nicolas has seen them in all the foals which he has examined at birth, and in several remount horses. They also exist in the dog (Möller), in the cat (Hirschberg, Berlin), the ox and pig (Möller, Schwalde), the rabbit (v. Ammon). Nicolas has seen sometimes the artery only, sometimes the artery and canal, and in some cases the canal only.

The canal and artery traverse the vitreous humour from the papilla to the posterior face of the lens; seen by the upright image in the horse, the canal may be as large as a goose quill, more or less regular or complete, of an opalescent tint, and rather diaphanous; the artery is seen in the form of a (usually fine) more or less complete vessel, clear red or greyish-brown. The posterior insertion of the cord is usually at the centre of the papilla, but Nicolas has seen it near the lower border by three branches of which only one was pierced by the artery. The anterior insertion is into the centre of the posterior capsule or into the periphery of the lens by means of a bundle of small fibres (Fig. 122) (Hirschberg in a cat and Nicolas in a horse).

Sometimes the cord is incomplete and is attached to the lens only, sometimes to the papilla only, when it forms a sort of cone projecting into the vitreous humour (Müller in an ox). The artery and canal oscillate with the movements of the eye. Together with these congenital vestiges, posterior polar cataract or lenticonus is often observed. The sight does not seem to be interfered with.

CHAPTER XI.

GLAUCOMATOUS AFFECTIONS.

In human ophthalmology certain conditions, the pathogenesis of which has not been well determined, are included under this heading. They consist essentially, from a symptomatic point of view, in an *increase in the intraocular tension (hypertony or hypertension).* The term glaucoma arose from the fact that as a rule there exists a greenish colouration of the pupil which struck the older observers and of which they made a pathognomonic symptom; in reality the yellow-green tint has not this importance, not being in the least characteristic of a morbid entity.

Hypertony, actually considered as the chief symptom of glaucoma, causes various alterations in the eye, which will be dealt with later. According to whether it acts on a resistant or non-resistant eyeball or not, the eye retains or undergoes increase of its normal volume. When the eye keeps its original volume it is said to be affected with true glaucoma, or simply, glaucoma; on the other hand, in cases in which the volume is increased the condition is called *hydrophthalmos.*

Glaucoma. Hypertony (*See* Tonometry) in acting on the vascular and nervous parts is shown in man by the engorgement of the anterior ciliary veins, by opacity, loss of lustre and sensitiveness of the cornea. The anterior chamber is diminished in depth, and the pupil is dilated. In the fundus oculi the retina and choroid atrophy, the retinal arteries become constricted in consequence of the small amount of blood which is admitted into their lumen, whilst the veins are full, dilated and become tortuous from the difficulty which they have in getting rid of their contents.

The region of the papilla, less resistant than the rest of the eyeball, since the sclerotic is here reduced to the lamina

cribrosa, allows itself to be pushed back just like a piston in its cylinder, producing *glaucomatous excavation* or *cupping* of the papilla.

This is recognised from the vessels of the retina, on arriving at the end of the papilla, forming a bend, and dipping down the sides of the excavation to go to the centre of the

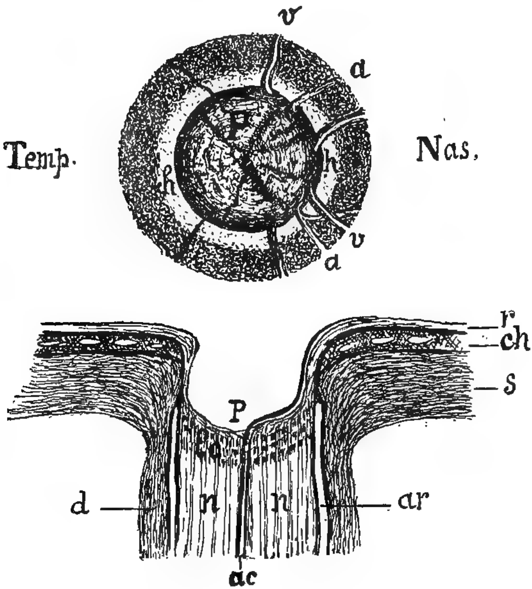


Fig. 136. The ophthalmoscopic appearance of the papilla of man in glaucomatous excavation. Below—The papilla seen in section (Fuchs).

P, *P*. papilla ; *n*, *n*, glaucomatous halo surrounding the papilla (a portion of the atrophied retina) ; *ac*, central artery of the retina ; *ar*, arachnoidal space ; *d*, dura mater.

papilla; from the vessels of the papilla and those of the retina being at different levels, and a displacement at different rates when seen by the method of parallatic movements. Besides this no complete idea as to the course of the retinal vessels

as a whole can be obtained except with the inverted image. By the upright image the vessels of the retina and those of the papilla cannot be seen at the same time on account of the difference in their refraction, one lot being diffuse because they are not focussed, while the other is quite clear for the opposite reason.

Glaucoma in man is not seen until about the fortieth year. According to the course which it takes it is described as acute, subacute and chronic. Acute and subacute glaucoma are met with in attacks causing a more or less acute pain in the eye, which spreads to the branches of the trigeminal nerve and causes head-ache, ear-ache and tooth-ache. Sight is always more or less dim, with alternating periods during which vision is better or worse. Externally the attacks may be accompanied by swelling of the eyelids, injection and œdema of the conjunctiva, and with the ophthalmoscope, exudative haziness of the media, giving the pupil a greenish reflection; these symptoms have led to this form being called *inflammatory glaucoma*.

Sometimes these attacks are preceded by hæmorrhages into the retina, produced as long as there is not yet any hypertension; this is *hæmorrhagic glaucoma* which is most often recognised in old men suffering from arterio-sclerosis.

Each attack leaving its contingent of lesions, a time comes when all the symptoms enumerated above are well marked, when the glaucoma is said to be confirmed.

In chronic glaucoma, on the other hand, the affection is developed slowly and insensibly without attracting attention by any striking phenomena; when failing sight leads to the patient being examined, the excavation of the papilla is seen to be especially marked. As for hypertony, it is relatively feeble, and in no way comparable to that which is seen following acute attacks and which make the eye as hard as a ball of ivory. Etiologically considered, glaucoma is said to be primary or secondary, according to whether it can be referred to an immediate cause or whether it has developed

as the result of a well determined pathological condition of the eye (irido-cyclitis, an ocular tumour, etc.).

Such are, quite briefly, the characteristics and principal appearances of glaucoma in man. This term is so often used in veterinary work, although the condition is a rare one, that it may be well to fix for the future the ideas of observers who are not familiar with the terms used in ophthalmology.

Glaucoma in animals. It may first be asked if glaucoma, as such, and judged from the objective signs which alone are properly appreciable in animals, really exists in the domesticated species. It does, but very rarely judging from the few well observed cases which bear criticism. Basing their diagnosis on the greenish colour of the pupil—a secondary symptom due to the presence of exudates in the media, many observers have suggested that periodic ophthalmia is the glaucoma of the horse, but since glaucoma is characterised by hypertension this view cannot be upheld; hypotension, on the contrary, being one of the characteristics of irido-cyclitis in the horse.

It must be mentioned, however, that in some cases, especially in the subacute forms of irido-cyclitis, there sometimes, but very rarely, exists a phase of hypertension, quite at the beginning of the attack and of very short duration. Here certainly there is a passing condition of glaucoma, but it is not followed by the group of symptoms which are met with in confirmed glaucoma in man. The excavation of the papilla, described by Hocquart and Bernard, in periodic ophthalmia is certainly due to an erroneous interpretation of symptoms, as Nicolas has shown. The eyes which they have described are atrophied, shrivelled, shrunken eyes, in which the papilla is found in the bottom of a funnel formed of folds of the retina, but which in no way recalls glaucomatous excavation or cupping.

Not only has spontaneous glaucoma not been recognised in the horse, but neither Möller nor Bayer has been able to produce it experimentally in this animal. The so-called

glaucoma of the horse is really hydrophthalmos, as will be described later; the same holds good for other animals.

Regarding spontaneous glaucoma in the dog, only two cases have been reported, both by Eversbusch. One, an old pug, had the condition in both eyes with fixed dilatation of the pupils and atrophy of the optic nerves. The arteries were constricted, the veins dilated, and both papillæ showed a glaucomatous excavation. The modifications in the ocular tension were not striking. The second case was seen in a draught dog which was completely blind in the left eye, and showed the same symptoms as in the preceding case. The volume of the two eyes was the same. [Gray has, however, seen secondary glaucoma in dogs, due to adenoma between the upper part of the eyeball and the orbit. As soon as the tumours were removed the increased tension disappeared].

The only experimental case is that of Berberich, in a rabbit, in which symptoms of glaucoma, with typical excavation of the papilla were developed without causing ectasia of the cornea or of the sclerotic. Hypertony led to the disappearance of the myeline or opaque nerve fibres in the retina and in the papilla.

Hydrophthalmos. This is the glaucoma of the child as well as that of animals. This form is not rarely observed in the horse and dog; Haussmann and Winckler have reported several cases in the ox. Schlösser, Berberich, and Bentzen have produced it experimentally in the rabbit. In this condition the intraocular pressure causes the eyeball to yield; the eye is distended in consequence of the increase of its liquid contents (*hydrophthalmos*); it is increased in volume (*buphthalmos*),* which can be recognised by the increase of the cornea in all dimensions (*keratoglobus*), the bulging of the eyelids, and the prominence of the eyeball in the head

* This term buphthalmos (ox-eye), permissible in the human subject, is not so in the horse, in which the volume of the eye is more than that of the eye of the ox under normal conditions. In the same way it cannot be applied to the ox. It is used here, however, as meaning an increase in the size of the eye. It is synonymous with megalophthalmos, the etymological meaning of which exactly describes the condition.

(*exophthalmos*). Besides the increase in its surface, the cornea is always more or less opaque; sometimes, in consequence of the whiteness resulting from the infiltration, it looks like eggshell. It is soon invaded by long, tortuous, thick ramifying vessels, few in number, which advance from the periphery

Chronic panophthalmitis in both eyes, with hydrophthalmos in the left eye, the result of bilateral luxation of lens.

to the centre in an almost radiating direction. The development of hypertony, and consequently of megalophthalmos,*

* Megalophthalmos may be determined by gases accumulated in the eye (ærophthalmos) as has been shown by Krusius in fishes. In these observations the gas was produced by an infection of the orbit.—(Archiv für vergleichende Ophthalmologie No. 2, 1910, p. 165).

is sometimes so sudden that it may be described as fulminant; Möller in a horse, Haussmann in a cow, and Cöster in a dog, have seen the eyeball increase to a considerable size in twenty-four hours; sometimes it occurs in attacks following somewhat closely on one another (Rémond), or at wide intervals: Nicolas followed a case of hydrophthalmos for five years in a horse; it remained stationary for four years and then suddenly began gradually, almost insensibly, to bulge, finally causing considerable increase in the volume of the eyeball. [Gray has seen it in the dog as a result of luxation of the lens].

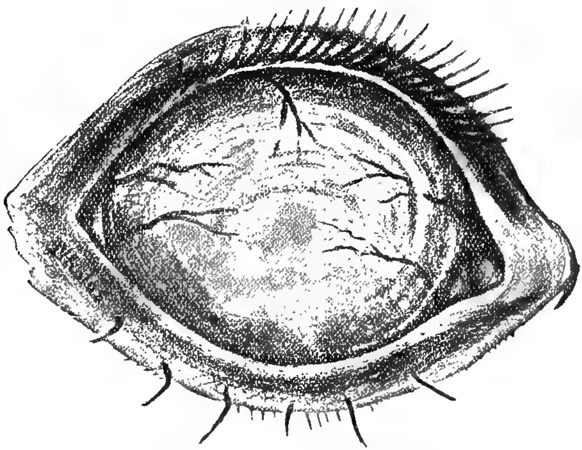


Fig. 137. Hydrophthalmos in the horse. Through the cornea, which is considerably enlarged, vascularised, and opaque (keratoglobus), it can be seen that the lens is luxated into the anterior chamber.

Reactionary symptoms—lacrimation, and more especially, photophobia—are not as a rule well marked, which proves, besides the fact that it does not respond so readily to the touch, that the sensitiveness of the cornea is diminished. The cornea is always more opaque during the attacks than between

them, but in spite of this it rarely becomes sufficiently transparent to allow the state of the anterior chamber to be seen. The aqueous humour is sometimes the seat of true inflammatory haziness.

The lens, of which the diameter cannot increase with that of the ciliary region, is freed from its attachments by the rupture of the zonula of Zinn, incompletely when subluxation is produced, or completely—luxation. In the first case it often falls into the anterior chamber in consequence of the symptomatic dilatation of the pupil, and can be seen through the milky white cornea by its denser white colour, and also on account of its movements.

Pathological anatomy. Some descriptions of this have been furnished by Dexler, Bayer, Möller, Bentzen, and others, showing that except for the increase in the volume of the globe, hydrophthalmos exactly resembles glaucoma. Atrophy of the iris, and of the ciliary body, a bending of the base of the iris against the cornea, and obliteration of the angle of the anterior chamber, known as "*Knies' adhesion*" have been recognised, as well as atrophy of the retina, of the papilla, and of the choroid, and in the dog (Bayer) and rabbit (Bentzen) only, excavation or cupping of the papilla.

A lesion peculiar to hydrophthalmos is increase in the volume of the eye, which from 38–50 cc. in the normal state in the horse may increase to 153 cc. (Dexler).

The diameter is increased from one to one and a half its normal dimension. In one case seen by Rémond, the cornea measured 3.5 cm. vertically and 6 cm. horizontally. As the area of the eyeball is increased its thickness is diminished; in a case described by Bayer, the sclerotic was reduced to the thickness of a sheet of paper and the cornea was not one-third its normal thickness.

In consequence of this distension the membrane of Descemet ruptures, and the epithelium fissures, and this is to some extent responsible for the opacity of the cornea. Haussmann has seen bursting (l'éclatement) of the wall of the eyeball in a cow in which the eyes increased in 24 hours to 4–6 times

their normal size (?). The lens is always more or less luxated, the vitreous humour opaque and turbid, and the retina is detached.

Etiology and Pathogenesis. As has been mentioned, in man it is possible to distinguish a primary and a secondary glaucoma. Its occurrence at about forty years of age in man, when arterio-sclerosis is most likely to be commencing, suggests that this is a cause, the rise of blood pressure denoting hypertony. Secondary or consecutive glaucoma

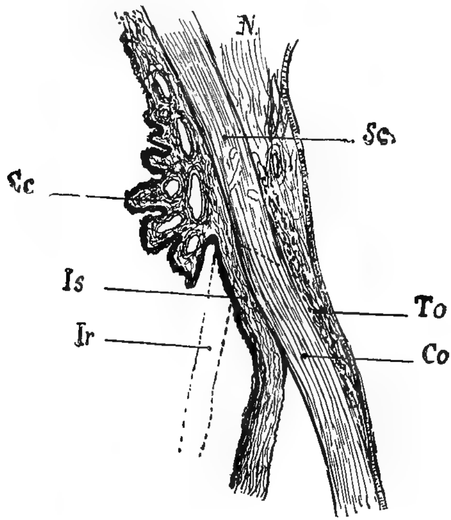


Fig. 138. "Knies' adhesion" (glaucomatous eye o man). In consequence of this adhesion (at *Is*) at the posterior surface of the sclero-corneal limbus the iris no longer occupies its normal position (*Ir*).

results from various causes which almost all act in the same way, viz., by hindering the filtration of the aqueous humour. The ocular tension being the result of an equilibrium between the secretion and excretion of the aqueous humour, it is very evident that, other things being equal, if the excretion is hindered the intraocular pressure rises.

Now amongst the causes which have been recognised by experiment and on post-mortem examination, the *closure of the angle of filtration* between the iris and the cornea seems to be very important. This closure is favoured by an inflammation which leads to an adhesion of the base of the iris with the cornea (Knies' adhesion) (Fig. 138), or, on account of obstruction of the reticulated tissue which is found at this part (and which forms a kind of drain), by inflammatory products (*retention theory*). These may be inflammatory exudates, as in uveitis, or crystalline masses, as in cataract. In experiments on rabbits, Schlösser in provoking a traumatic cataract, Berberich a purulent iritis, and Bentzen a mechanical irritation of the angle between the iris and cornea followed by a Knies' adhesion, have all been able to cause a glaucomatous or hydrophthalmic hypertony.

Concerning the causation of hydrophthalmos it must be admitted that in man this form of glaucoma, particularly seen in the child and most often congenital, is due to a feeble resistance of the walls of the eye. This explanation does not coincide exactly with what is observed in domesticated animals. In them, hydrophthalmos is sometimes of congenital origin (Dexler, Eberhardt in the foal, Keil in a calf), but it is also acquired, and may be developed at any age, and consequently in conditions in which the feeble resistance of the sclerotic cannot be incriminated, especially in the horse. The thickness of this membrane, and the closeness of its texture render it a very resistant structure. Here the mechanical theory seems to be quite insufficient. [In dogs, it sometimes arises from a tardy and therefore an incomplete reduction of a luxated eye, as well as a primary luxation of the lens. In the cat it may arise from tubercular choroiditis].

Prognosis. Hydrophthalmos, more surely and more rapidly than glaucoma, leads to loss of vision.

Treatment is directed towards lowering the intraocular tension, either by the depressant action of miotics, by paracentesis, or by iridectomy; as adjuvants diuretics and purgatives may be given.

Eserine and pilocarpine in instillations of 1–2 per cent. by contracting the pupil and drawing back the iris, tend to open the filtration angle, and have a favourable action, but the effect soon passes off and thus necessitates frequent instillations, which should be continued till the hypertonus has disappeared. These two alkaloids are especially indicated in man at the commencement of an attack; when they do not give a sufficiently rapid result, recourse may be made to paracentesis and iridectomy. Badal has also suggested the severing of the external nasal nerve by exposing it and stretching it until it breaks, which is often followed by a lowering of the intra-ocular tension.

In hydrophthalmos in animals, if miotics do not stop the course of the megalophthalmos, intervention should be made by paracentesis of the cornea (Hertwig), but this must be done carefully so as to avoid a too rapid escape, which leads to serious complications.

In practising this treatment Nicolas and Rémond saw the sudden reduction in pressure lead to hernia of the vitreous humour, and abundant hæmorrhage into the anterior chamber, followed by atrophy of the eyeball. A small puncture only is therefore advisable so as to allow the vitreous humour to escape drop by drop. [Some practitioners, however, prefer using a narrow lancet or a von Græfe's knife to a paracentesis needle]. Winckler claims to have had a good result (?) by aspiration of the aqueous humour by means of a syringe. For reasons already given iridectomy seems to be little indicated. [Hill had good results by repeated paracentesis in a dog, internal administration of potass. iod., and the application of tincture of iodine round the orbit].

If in the course of the development of the disease the eye becomes very troublesome in consequence of being exposed to further disturbance from abrasions, and keratitis sets in from the inability to close the eyelids (lagophthalmos), enucleation or evisceration may be practised, as has been done in such cases by Schimmel, Jorge and numerous others.

Panophthalmitis. Etymologically this term might be applied to any inflammation in which the whole eye is affected. Under this head, therefore, the plastic irido-choroiditis of the horse may be included, but it seems better to reserve this term for acute suppurative inflammation of the eye, which as a rule very rapidly leads to its destruction. Strictly speaking there is no very clear boundary between acute plastic irido-choroiditis in the horse, for example, and panophthalmitis or purulent irido-choroiditis, as it is also called; the whole difference lies in the virulence of the causal organism, as has been mentioned with regard to Dor's experiments on periodic ophthalmia. Nevertheless, the special etiology, the well-defined symptoms, and the particularly serious prognosis make a special clinical form of panophthalmitis.

Etiology. It is not impossible that the pyogenic infection may be endogenous and result from embolic processes. Gmelin has seen panophthalmitis following on a broncho-pneumonia of the horse with the formation of multiple cavities. In a newly-born goat examined by Leber and Addario, the infection had occurred during fœtal life, probably by way of the blood stream, for no trace of any external traumatism could be found: a bacillus which was not recognised could be seen inside and outside the leucocytes. [Gray has seen it in the cat and dog during distemper; it has generally run a rapid course, ending in destruction of the eye within 24 to 36 hours. It could, in his experience, arise without corneal ulceration]. More commonly the infection takes place exogenously; accidental or surgical penetrating wounds or perforating ulcers may cause the condition.

Symptoms. The symptomatology may be somewhat different according to whether the infection is internal or external in origin, and also according to its point of commencement. If it is developed in the depth of the eye the external symptoms are at first but little apparent; they only attract attention when the inflammation has reached the anterior segment of the eye. Nicolas, by the inoculation into the vitreous humour

of several rabbits of a culture of the staphylococcus albus, has been able to produce the following symptoms: as the suppuration increased it gave a whitish reflection to the pupil which could be seen from a distance, and which at first might be taken for a cataract. Some days later a fine circumcorneal injection was noticed denoting the invasion of the ciliary body, then an intense congestion of the iris causing hæmorrhages into the anterior chamber. The whitish reflection of the pupil became more and more marked as the pus advanced towards the lens; the anterior chamber was soon invaded. The peripheral vascularisation of the cornea, at first discrete, at last reached the centre forming a thick red ring. The cornea increased in size and became conical, while the whole eye was distended and protruded between the lids (exophthalmos). The infection took fifteen days to reach this point, after which resorption commenced, and ended in atrophy without perforation. When the infection is external in origin the symptoms are much more striking. The exterior of the eye has all the appearances of a violent inflammation; the eyelids, very much swollen, completely cover the eye, and it is sometimes quite difficult to see that the cornea is red, infiltrated, and chemotic. An abundant purulent secretion accumulates at the margins of the lids. The opalescent cornea more or less allows the purulent hæmorrhagic exudates to be seen filling the anterior chamber; it becomes vascular at an early stage, infiltrated, and may ulcerate even to perforation.

As a rule the wound which is the cause of all the trouble serves as a valve, and allows the purulent discharge to find exit. If the wound is in the cornea the herniated iris forms a dark red granulation which is constantly discharging and is covered with a fibrino-purulent membrane. If the wound is at the edge of the sclerotic it gives passage to a blackish granulation formed by the choroid or the herniated ciliary body, from the edges of which pus exudes mingled with granules of pigment.

Then all the phenomena are reversed in the same order; the inflammation diminishes, the eyelids assume their normal shape and suppleness, the conjunctiva is freed from œdema, the purulent secretion diminishes, while the eye becomes soft and atrophies more and more. After six weeks to two months the eye is often reduced to a shapeless mass in which it is difficult to recognise the cornea from the sclerotic.

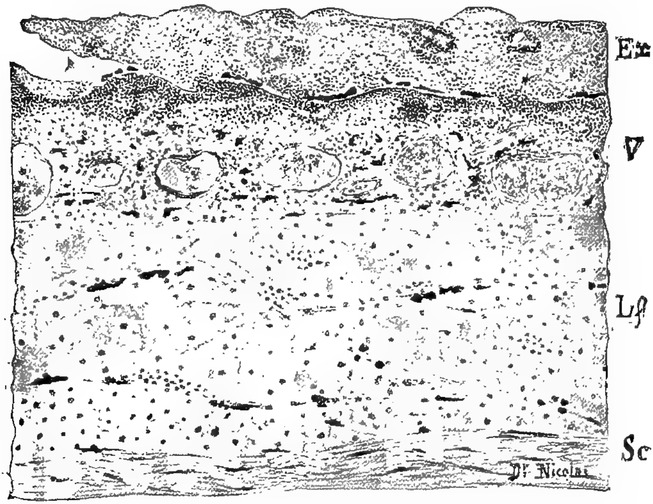


Fig. 139. Choroid of a horse in panophthalmitis.

Sc, Sclerotic. *Lf*, Lamina fusca, the meshes of which are swollen with fibrin. *V*, The layer of large vessels which has almost entirely returned to its embryonic condition; the lumen of the vessels is filled with fibrin and their walls have to a great extent disappeared. *Ex*, Exudate on the surface of the choroid, separated from it by some traces of the pigmentary layer of the retina.

Henceforth the orbit is too large for the eye and the lids fall in in front of it like two vertical covers.

Pathological anatomy. An account of the alterations which an eye attacked with panophthalmitis may undergo will be given in the following data relating to a case of accidental

perforation of the cornea of the horse while the inflammation was in the acute stage: The eye was not atrophied, but very tense. There was considerable subconjunctival and intra-muscular œdema, all round the eye. The cornea was infiltrated, and perforated along a linear wound through which the iris was protruded. The anterior chamber was full of pus and blood. The iris was covered, and infiltrated by a fibrino-purulent exudate. The vitreous humour was replaced by a sero-purulent and hæmorrhagic fluid. The whole of the cavity was covered by a thick hæmorrhagic exudate forming a resistant membrane, easily detached from the sclerotic and dragging with it the choroid to which it was intimately attached. The ciliary body and lens were covered by the same exudate. The retina had completely disappeared.

Under the microscope the choroid was to some extent blended with the exudate which penetrated and covered it, the whole only constituting a membrane formed of fibrin, embryonic cells, and some pigment cells surrounding the remains of the vessels (Fig. 139). The ciliary body and the iris showed the same alterations.

Diagnosis. The violence of the external inflammatory symptoms immediately suggests the idea of an affection of the eye from an external wound. Some contusions of the eyeball and the lids may, however, give rise to the same appearances; but while in these cases the eyeball is almost intact, in panophthalmitis, on the contrary, the external symptoms are accompanied by disturbance of the media of the eye. The diagnosis is certain in the presence of a penetrating wound of the eye which shows the above-mentioned characters, and to find this it is sometimes necessary to search under the eyelids (Nicolas).

Prognosis. Sight is irremediably lost. Further, the eye is certain quickly to undergo atrophy. The value of the animal is therefore depreciated from the point of view of usefulness as well as appearance.

Treatment. In these conditions therapeutics can have no other object than the arrest of the suppuration, and lessening the duration of the affection. Also to prevent possible complications of the brain and, though the present state of knowledge on the point is very problematical, to prevent sympathetic ophthalmia. First, fomentations and the application of antiseptic lotions to the eye, the lids being drawn apart. To this may be added, as soon as the disappearance of the œdema of the lids allows it, subconjunctival injections of cyanide of mercury (2–5 cc. of a $\frac{1}{2}$ per cent. solution in sterile water). In one case Brun obtained good results in a horse by the intravenous injection of collargol (40 centigrammes in suspension in 10 cc. of water).

The wound should be dusted with iodoform, and if the opening of the eye from suppuration is to be feared there should be no hesitation in hastening it with a bistoury. Lastly, the eye should not have any dressing to close it, so that there may be a free exit for the secretions; however, a hood may be applied, without any cotton-wool dressing under its eye-shield, in order to protect the eye from the light, from chaff and straw, and from flies.

Sympathetic Ophthalmia. Every affection, according to Gama Pinto, transmitted from one eye to the other internally but without contagion is said to be sympathetic. The eye which gives the affection is called the *exciting* eye, that which receives it is spoken of as the *sympathising* eye.

In man it is chiefly accidental—traumatic, or infected operation wounds which cause this sympathetic affection. Panophthalmitis is believed to have a sympathising effect. As for the other affections, such as uveitis, corneal ulcers, and intraocular neoplasms, etc., their *rôle* is very doubtful. [Some authorities, however, consider they may form the starting point of sympathetic ophthalmia whilst purulent panophthalmitis does not give rise to the disease in the other eye].

Sympathetic ophthalmia usually presents itself in the form of an uveitis (irido-cyclitis, irido-choroiditis), or more rarely as a neuroretinitis, and commences as a rule about three to

five weeks after the exciting affection. The duration from transmission may however be much longer, but as this period becomes longer and longer the diagnosis of sympathetic ophthalmia becomes proportionately less certain. [There is no evidence that sympathetic ophthalmia, as known in man, occurs from accidental or operative wounds or injuries of the eyes in our domesticated animals; if it does occur it must be very rare, judging from the experience of those who have had good opportunity to observe it].

Only experimental data concerning sympathetic ophthalmia in animals can be given. This is not because the expression has not been used to qualify certain cases of ophthalmia developing in one eye, followed by the other eye showing certain alterations. Cases of irido-cyclitis in horses affecting one eye after the other may thus be explained: the eye first attacked transmitting the affection to the second by sympathy; but in all cases so described there has been no proof. The only observations to which much credit can be given are those of Darrou (1906), which he recorded with particular care and attention. A horse having shown symptoms of irido-cyclitis in one eye, Darrou in each case examined the other eye every week, and thus saw in three cases, at an interval of from one to two months, an inflammation of the choroid and neuroretinitis set in, and this extending to the anterior regions gave the appearance of a case of irido-cyclitis. [Gray observed an acute panophthalmitis after enucleation of the other eye so affected in a cat suffering from distemper. It, however, ran a rapid course].

Experimental data. By irritating the sclero-corneal limbus, or even the iris itself, on one side in rabbits, Mooren and Rumpf, and Gründhagen and Jesner, have caused ciliary injection in the other eye, with a discolouration of the iris and sometimes a cloudiness of the aqueous humour, all being vascular phenomena which they agree in regarding as of a *reflex nature*, the irritation being transmitted by the ciliary nerves. But these are facts which must be differentiated from sympathetic inflammation which is infective in nature, the infection being

propagated from one eye to the other by the optic nerves. By injecting various infective agents, especially staphylococcus pyogenes, into the eyes or into the tunics of the optic nerves of rabbits, Deutschmann has succeeded in causing sympathetic ophthalmia, although others in repeating his experiments have not always had the same results.

Treatment. The special treatment of sympathetic ophthalmia consists in the *enucleation of the exciting eye* in order to preserve the sight of the other, before it becomes affected, or if it has already done so, to arrest the course of the disease. This operation, performed in human ophthalmology, has been advised in the treatment of periodic ophthalmia in the horse. It has even been tried by Boellmann on a horse which, affected with ophthalmia on one side, showed a luxation of the lens of the other eye. This, considered as exciting, was removed and replaced by an artificial eye. Until there are more details, and we are more certain as to the reality of sympathetic ophthalmia in animals and the conditions under which it develops, any such intervention seems to be premature. Allowing that the eye to be removed is functionally useless it can always advantageously be replaced by an artificial one to give the animal a better appearance.

Displacements of the Eyeball. Exophthalmos. According to the species and to the individual the eye may be more or less pronouncedly salient outside the orbit. In bovines it is generally more prominent than in equines, especially in fat animals, fat being deposited in the orbit in a relatively large quantity. According to Dexler the volume of the orbit may be to that of the globe as six is to one in the ox, whilst in the horse it is only as two is to one. But it is especially in the smaller breeds of dogs that the protrusion is most marked, and is quite an ethnological character. Pugs and King Charles, [Japanese and Pekingese] spaniels are remarkable in this respect. [It may be here mentioned that these breeds have not such an acute corneal reflex as those breeds of dogs having less prominent eyes].

Exophthalmos has therefore nothing very characteristic, and it is necessary, if it is to be taken as a pathological symptom, that the species or breed of animal be taken into account; also the previous history of the individual must be examined and compared with his present condition if the protrusion is double, or with the other eye if it is simple, which is the most common condition.

Many different *causes* have been reported in animals; *fracture of the orbital arch* with backward displacement of the fractured parts (Vachetta), inflammatory tumefaction of the orbit, œdema, or an abscess (Nöhr), or a hæmatoma following on a punctured wound, or to some general disease such as purpura hæmorrhagica (Ciattoni, and Blin). [Acute orbital cellulitis not rarely gives rise to it in the horse. Tuberculous growths in the orbit are frequent causes both in the cat and dog. It is the same in the bird, which has also the eyeball displaced by the cheesy or fibrinous exudate arising in the oculo-maxillary sinus during diphtheria]. After bleeding a horse Berlin saw the development of a thrombophlebitis which reached the venous sinuses of the brain, and ultimately led by venous stasis to a *double* exophthalmos so marked that the eyelids could not cover the eye. Intraorbital tumours (Kampmann, Werner, and Cuillé and Sendrail in the ox, and Möller, [and Gray] in dogs) as well as tumours developed in the walls of the eyeball (Pétit and Coquot in the horse) may lead to the same result. Rivolta saw the condition in a goat, caused by a chronic myositis of the intraorbital muscles. Anatomical examination showed that there was an abundant infiltration, with small round cells, and an increase in the muscular tissue (Vachetta).

An observation by Besnoit may be quoted. In a case of tuberculosis of the meninges and of the right cerebral hemisphere of a cow, he saw, at the same time as the cerebellar symptoms, a right exophthalmos the pathogenesis of which he could not explain.

Besides this exophthalmos from local causes, generally unilateral and accompanied by strabismus, there is another

form, usually double, even less understood with regard to its causes in man, in whom it has been specially studied; this is exophthalmic goître, concerning which a few observations have been made in animals. This collection of symptoms was recognised for the first time in veterinary medicine by Jewsejenko (1888) in a mare and in a bitch; it has since been seen by Cadiot in a horse and Ries in a mare, Albrecht and Sonnenburg in a dog, Röder, Göring, and Cozette in the cow, and more recently by others. The animals observed by Cozette being tuberculous, the author drew attention to the relationship between tuberculosis and Graves' disease in human medicine.

It is essentially characterised by the following three symptoms: acceleration of the movements of the heart, or tachycardia, swelling of the thyroid bodies, or goître, and exophthalmos; these symptoms being as a rule successively developed, and in the order in which they are here given.

In the human species exophthalmic goître, Basedow's or Graves' disease, is most often met with in women during the period of activity of the uterus. Its development is usually slow, and death is one of its terminations. According to experiments by Stilling (1891), the disease is nervous in nature and due to a functional disturbance of the sympathetic which by producing arterial stasis in the carotid region leads to swelling of the thyroid and exophthalmos.

Diagnosis. Unilateral exophthalmos is easy to recognise. When it is double, it cannot be accepted as a pathological condition unless a careful examination of the conditions of its development has been made. First Graves' disease may be thought of. The symptom of exophthalmos being recognised, its cause must be determined. To do this it is necessary to know whether the exophthalmos is reducible or irreducible, and this can be discovered by exercising pressure on the surface of the eye as if to force it back into the orbit. If it is irreducible it is probably due to the presence of a tumour.

Taken alone, exophthalmos necessitates a grave prognosis

being made, as during its development it exposes the cornea to dessication and ulceration (*lagophthalmos*).

Treatment consists first in suppressing the cause: excision of the tumour, bromide of potassium and digitalis in goître. In this last case Ries has performed thyroidectomy on one side and exothyropexia on the other (luxation of the thyroid and then fixing it to the skin over it, an operation devised by Jaboulay and Poncet in 1894 to avoid cachexia strumipriva) which had the effect of reducing the volume of the gland by half; the results of this operation were not reported.

To protect the cornea from accidents arising from lagophthalmos the internal angle of the eyelids may be sutured (*internal tarsorraphy*) to diminish the palpebral opening. [Thyroid extract is contra-indicated; but the serum of animals deprived of their thyroids may be used to advantage].

Luxation and Avulsion of the Eyeball. This is the condition in which the eye is completely outside the palpebral fissure; it is usually the result of traumatic influences, blows, kicks or scratches, in dogs and cats. [In the small spaniel-class of dog, as the King Charles', Pekingese and Japanese, the eyeball is sometimes luxated in drawing the skin of the head and neck backwards in holding the animal, especially during struggling; also Gray has seen the luxation of one eyeball occur whilst the other luxated eyeball was being reduced. In the horse it has sometimes been produced by blows across the orbital arch from the twitch or the farrier's hammer].

Treatment consists in *replacing* the eyeball if it is intact and has left sufficient nervous and vascular communications for its nutrition. After disinfection, draw the upper eyelid on the eyeball and by its aid push the eye into its cavity. [In cases of simple luxation, seen almost immediately after they have occurred and before exudation has taken place in the areolar tissue under the conjunctiva, from constriction of the eyelids on the eyeball, merely smearing the eyeball with

castor oil or neutral vaseline and then drawing up the eyelids, each held between the thumb and index finger of each hand of a careful assistant, whilst the eyeball is being gently pressed back or downwards into the eye-socket, is generally sufficient to reduce the luxation]. In more difficult or neglected cases in order to facilitate the operation compresses soaked in a solution of cocaine are made use of, and the palpebral opening is enlarged by a cut with the scissors at the external angle; then, to keep the eye in position, two or three sutures are inserted in the lids and kept in place for a few days, as advised by Härtle and Peuch in the dog, [care being taken that the sutures are so placed in the eyelids that they do not press on the eyeball so as to irritate the cornea and set up ulceration and perhaps destruction of the organ of sight. Leeches or scarifications may be necessary to remove some of the extravasated blood under the conjunctiva]. Hot fomentations help to restore the eye to its normal vitality. [Some practitioners, in order quickly to reduce the luxated eyeball, decrease the dimensions of the eyeball by evacuating some of the aqueous humour. This is, however, rarely necessary, and perhaps always objectionable in consequence of adding fresh injury to the already injured organ. The same objection cannot be raised against the use of ice-compresses to reduce the eyeball and to prevent a threatening panophthalmitis or hydrophthalmos].

In cases in which replacement is not possible, extirpation of the globe should be practised. This is quite simple when the eye is only adherent by a few muscular fibres, which is not rare; in a case mentioned by Poncet in a dog the optic nerve was torn. [Where much force has to be maintained to keep the eyeball within the eyelids after it has been replaced, the eye generally becomes the seat of hydrophthalmos. Under these conditions Gray thinks it is advisable to enucleate the eye at once].

Enophthalmos. This is the reverse of exophthalmos: the eye is abnormally sunken in the orbit. In the pig the eyes

are so slightly salient that the term "pig-eye" is applied to a sunken eye in other animals.

Enophthalmos may be congenital and connected with microphthalmos or cryptophthalmos, or acquired and due to several causes, such as atrophy of the fatty cushion in marasmus, and in excessively thin animals; to tonic spasm of the posterior straight (choanoid) muscle in tetanus; and in many of the wasting and also the chronic painful diseases in all species].

Enophthalmos may also be produced by a traumatism. Lee observed a case in a horse consequent on a blow from the cavesson in which the eye-pit was filled up; by pressure exerted in this region the eye came back into place. A subconjunctival hæmorrhage was found, but vision was not interfered with. [Gray has seen it in the dog associated with atrophy of the masseter and other facial muscles consequent on paralysis from an intracranial tumour pressing on the root of the fifth cranial nerve. In the cat enophthalmos is very common, especially during distemper, anæmia, and certain prostrating conditions; it seems to be connected with some disturbance of the sympathetic nervous system. In cerebral meningitis, cerebral intoxication, irritation of the eyes, painful ulceration, and other inflammatory conditions in the smaller animals, it is not rare. Any stimulation of the anterior surface of the eye may produce temporary enophthalmos by reflex contraction of the choanoid muscle when the membrana nictitans protrudes over the front of the eyeball].

Lastly, different observers have proved by experiment that extirpation of the superior cervical ganglion and section of the sympathetic nerve produce enophthalmos, as well as other symptoms in the eye, such as miosis, hypotonus, etc.

In a thoroughbred horse showing cataracts, and a slight strabismus of congenital origin, Nicolas observed the complete collection of symptoms associated with paralysis of the cervical sympathetic nerve, which doubtless had the same origin. The sunken appearance of the eyeball gave one the

idea of atrophy of the globe, which taken together with the cataract and the hypotonus, led to a diagnosis of irido-cyclitis. The abnormal prominence of the membrana nictitans pointing to retraction of the eyeball, allowed the proper value to be assigned to each of the symptoms presented.

Contusions of the Eye. These have given rise, experimentally, to the following interesting facts: In the *anterior chamber*, fibrinous exudates (Berlin and Bauer), due to traumatic lesions of the vessels allowing transudation of albumen from the blood. In the iris, to iridodialysis. In the lens, to subluxation or luxation; to star-shaped or radiating images situated in the anterior or posterior layers and disappearing after a certain time (Back, Wintersteiner); to cataracts (Volkers). In the retina to a milky opaqueness at the point actually struck and at a point diametrically opposite to it, which Berlin attributed to œdema, and Back to an exudate from the choroid of the same nature as that in the anterior chamber; they disappeared in two or three days. In the choroid, to hæmorrhages or ruptures. Experiments by Panas and Moll have shown that traumatisms of the eye render it liable to infection by metastasis; this has, however, been contradicted by Stock and Wojzechowski. [These conditions occur very commonly in all our domesticated animals, from brutal or accidental injuries; they are particularly common in horses working in coal-mines running their heads against projections of rock. Perforating wounds of the eyeball occur sometimes in horses by putting their heads through a window and injuring the organ with the broken glass. A poke in the eye with the stablefork, a sharp stick, or a bullock's horn, also cause similar conditions. Blows or other injuries sometimes cause extravasation of blood into the subconjunctival areolar tissue covering the eyeball and entering into the formation of the eyelids. In man, in consequence of his pigmentless skin, it is characteristically known as "black-eye."]

Foreign Bodies in the Eye. Experiments by Leber, confirmed by Kostenitsch and Schmidt, have shown that only

aseptic and chemically inactive foreign bodies can be tolerated in the eye where they remain free or encapsuled. After a time, however, they often produce atrophy or detachment of the retina. Gold, silver, glass and zinc (Volbert), are chemically inactive, while the metals which are easily oxidizable, such as iron and copper, give rise, especially the latter, to suppurative, non-bacterial inflammations which may be resorbed. In dissolving, iron and copper produce deposits or incrustations of the coloured oxides. Ovio (1895) has shown the great tolerance of the eye to small shot from firearms; firing at rabbits and boxes full of gelatinised bouillon, with shot soiled with pyogenic organisms, neither in the eyes nor in the boxes was he able to see any growth of the organisms.

On the other hand he was able to introduce aseptic small shot into the anterior chamber and vitreous humour of rabbits without the eyes showing, six months after, any other anomalies except the visible presence of the foreign bodies.

The Parasites of the Eye. Nematodes are fairly often found in the eyes of animals. *Filariæ*:* *F. palpebralis* in the horse and *F. (Thelazia) lacrimalis* in the ox, are found in the conjunctival culs-de-sac and more commonly under the membrana nictitans, in the passages of the lacrimal glands and in the lacrimal canals; they cause a more or less marked conjunctival irritation, opacity, and sometimes ulceration of the cornea. *F. inermis* and *F. papillosa* in the horse and ass, *F. labiato-papillosa* in the ox, are met with in the aqueous humour; [*Thelazia Leesei* in the vitreous humour and conjunctival sac of the camel;] *F. oculi canini* in the vitreous humour of the dog. *Spiroptera* living in the conjunctiva of birds may cause a violent purulent inflammation, as has been described on p. 119. [Various parasites have also been found occupying the eyeball, conjunctival sacs, and the oculo-maxillary sinus in different species of birds, especially aquatic

* [Railliet includes most of these eye-filariæ in the genus *Thelazia*. *Vide* an excellent paper on "Ocular Filariæ of Equines and Bovines," by Lingard, in *Journ. Trop. Vet. Science*, Vol. i, No. 2, 1906, p. 175].

birds. Gooch found an undetermined species of leech (?) in the conjunctival sacs, nostrils, and oculo-maxillary sinus in ornamental swans.*

According to Mégnin † the *Monostoma mutabile* and the *M. sarcidiornicola* as well as the leech, *Glossinia tessellata* are not infrequently found in the infraocular sinus and air-passages of ducks, swans, and other water birds and in poultry. Small, ‡ of Dublin, in 1862, recorded the presence of small black leech-like worms in the anterior chamber of eye in geese. These worms, which only attacked one eye, caused keratitis and eventually panophthalmitis].

Filaria papillosa of the horse or *F. oculi equini* has been recognised in small numbers everywhere but especially in India, and must be described. It is the larval form of *F. equina* which lives in the adult state in the peritoneum and serous membranes (Neumann).

Usually 2–4 cm. long (exceptionally up to 12 cm., Bagge) and 1 mm. thick, they look like "small snakes" moving in the aqueous humour. They can be seen developing in this medium, and may be destroyed or even resorbed in the eye (Francis). It is rare to find more than one at a time, but several may be seen in succession (Bayer).

Different alterations in the eye which have been met with at the same time as the filaria, have been attributed to its action, but it is quite possible that they are merely coincidences. Be this as it may, central ulcerations of the cornea (Monod), various corneal opacities, which may render the aqueous humour milky (Léger), keratitis punctata profunda, opalescence of the aqueous humour, iritis, and more or less extensive opacities of the lens have been reported. [In Leese's case of "ophthalmia" in the camel, a filaria (*Thelazia Leesei*) was present in the vitreous humour.

Symonds** reported a case in a horse in which after the

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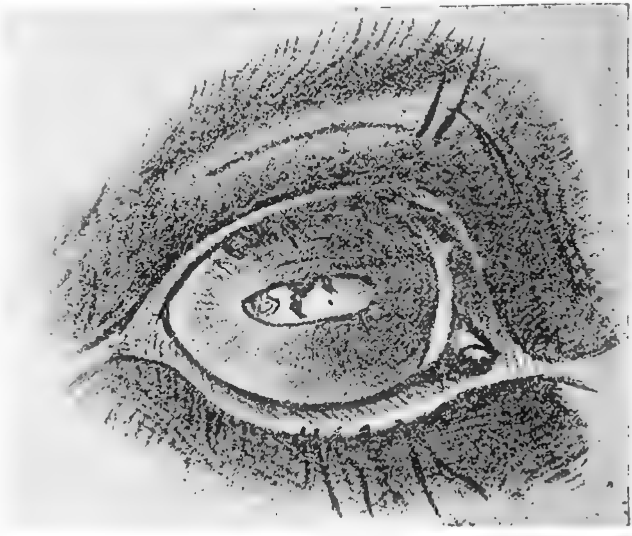
* *Veterinary Record*, Vol. xvi, 1903-1904, p. 248.

† Mégnin, Médecine des Oiseaux, 1906, Vol. i.

‡ *The Veterinarian*, 1862, p. 15.

** *The Quarterly Journal of Veterinary Science of India*, Vol. i, 1883, p. 476.

opaqueness of the cornea and anterior chamber began to clear up the parasite was found attached by one of its extremities to the iris, whilst the other was free and moved easily about. Ten days, or thereabouts, later the worm was found dead and the free extremity detached and in the bottom of the anterior chamber, whilst the other portion still remained adherent, at least in two places, on the iris. A



Dead Filaria Oculi attached to the Iris and projecting into the pupillary field in the eye of a Horse. (After Symonds).

portion of a corpus nigrum seemed detached by the movements of the worm, and was directly in the centre of vision, adherent to the anterior lens-capsule, as shown in the figure].

Some of these alterations recede after the disappearance of the parasite.

The only *treatment* applicable to filaria in the eye is *extraction*. Paracentesis of the cornea, after the application of cocaine, performed in a dependent part with a lancet or paracentesis

needle (*See* Fig. 71), allows the aqueous humour to escape and bring with it the filaria. If the parasite does not escape it must be removed by means of fine forceps introduced through the wound in the cornea. [According to General Smith, who has had great experience in this direction, the great difficulty is to determine whether the parasite has escaped with the rush of fluid. It is generally found on the sleeve of the operator, hence a black coat aids in their detection]. The after-treatment is simple.

Cestodes are more rarely met with. Cysticercus cellulosæ affects the eye of the pig. Outside the sclerotic, conjunctiva, or the eyelids, the "measle cysts" are able to be diagnosed during life (Prettner, Kukuljevic); they are most commonly post-mortem discoveries, although in the vitreous humour and under the retina they may be seen with an ophthalmoscope.

In 400 "measly" pigs at the abattoir at Prague, Prettner has found cysts under the retina in two cases, 17 times in the eyelids at the internal angle, and in 20 per cent. of the cases in the muscles of the eye, but in these the affection was always generalised to the muscles of the neck, jaws, etc. In the pig also Kukuljevic has twice seen "measles" cysts the size of a pea on the sclerotic and twice in the vitreous humour. In cases of intraocular cysticerci in man, enucleation is practised. The *cœnurus serialis* has been found in the orbit in the rabbit, aspergilli in birds, and sarcocysts in various animals.

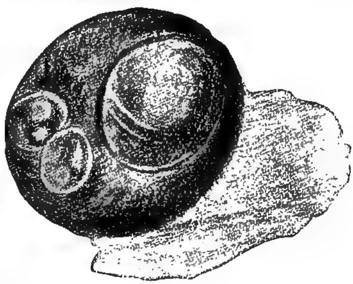


Fig. 140. Eye of a pig having on the sclerotic, near the cornea, two vesicles due to "measles" (*cysticercus cellulosæ*) (after Kukuljevic).

Congenital Anomalies. *Anophthalmos* and *cryptophthalmos*. *Anophthalmos* or complete absence of any organ of vision has

been described, in a male guinea-pig which was parent to five similarly affected young, by Guinard. In all there was a complete double anophthalmos, *i.e.*, absence of the eye, of the optic nerve and of the nervous centres dealing with vision. More commonly, however, there are traces of an eye when a careful examination is made; there is in reality *cryptophthalmos* (hidden eye); a case seen by Lesbre and Forgeot in a foal which had an optic nerve, a chiasma and normal corpora quadrigemina, but no trace of an eyeball, can thus be named; also similar cases by Cadéac in a foal, Bary, Morot, and Albrecht in the calf, of Sgrosso and Velhagen in the pig, Bach in the rabbit, of Gillet, Grammont, Collins and Pearson, Hess, Karman, and van Duyse, in birds. [Gray has seen a litter of in-bred white Old English sheepdog pups some having double cryptophthalmos, others single with microphthalmos, and one had one normal and one microphthalmic eye. The cryptic eyes were no larger than a hempseed and were provided with muscles; they were hidden deeply in the socket behind the membrana nictitans, which was in some instances well developed. In other instances the eyes could only be found by dissection. The iris was of a palish blue colouration, and the eyeballs were nystagmic. Becker, of Breslau, encountered a dozen sows in the same establishment giving birth to young that were all blind, some from absence of eyes, others from rudimentary organs; in others born with an eyeball, pustular keratitis destroyed the bulb. He attributed it to the boar and consanguinity].*

The muscles of the eye may be normally developed as in the case seen by Cadéac, the opening of the eyelids may be normal, but the palpebral fissure is often reduced to a small hole or may sometimes be completely absent (congenital ankyloblepharon).

Cyclopia. More or less complete fusion of the two eyes in one in a median plane has been met with a good many times in animals, especially by Phisalix (dog and sheep), Moussu, Gabrielides, Schmidt (pig), etc. A complete comparative

* *Veterinary Record*, Vol. xviii, 1910-11, p. 197.

study of this question will be found in "Les Eléments de Tératologie de l'Œil" by Van Duyse in the Encyclop. française d'ophtalm., Tome ii.

[*Microphthalmos* is the term applied to the small condition in which the eye is found from imperfect development, and is seen in all the domesticated animals. It may be single or double and is often associated with other congenital abnormalities such as superior or supero-internal strabismus, nystagmus, aniridia, etc. A whole litter of pups may be so affected].

Surgery of the Eyeball.

Enucleation of the Eye. This operation consists in removing the eyeball and leaving the muscles and the fatty mass at the back of the orbit, which, surrounded by the conjunctiva, form a stump at the bottom of the orbit.

The animal should be completely anæsthetised; in the case of a horse local anæsthesia alone may be used, and is best effected by subconjunctival injections of a four per cent. solution of cocaine or novocain with adrenaline at the four cardinal points of the eye. [Gray usually relies on local anæsthesia for the cat and dog].

Bonnet's method. Seize the conjunctiva in the neighbourhood of the upper region of the sclero-corneal limbus, incise it with curved scissors, and detach it all round the cornea and

Fig. 141. Strabismus hook.

for a depth of about 1 cm. Under the conjunctiva thus detached introduce a strabismus hook,* pass it under each of the four tendons of the recti muscles, which are then raised up and cut through with the curved scissors quite near the sclerotic. The eyeball, freed from the recti muscles, is seized from the external side and drawn back as if to luxate it towards the nasal angle; this allows the curved scissors to be

* The length of the curved part of the hook for horses should be 2 cm.

introduced by the temporal angle into the depth of the orbit, and the posterior rectus or retractor muscle and the optic nerve to be cut close to the orbit. The eyeball is then completely luxated, and it only remains to cut the two oblique muscles.

[Gray's method of enucleating the eye in small animals is to seize the eyeball with a pair of serrated fixation forceps provided with a catch, the conjunctival membrane at the upper sclero-corneal margin is cut through with a good pair of blunt-pointed curved scissors, cutting well at their free extremity, the eyeball then tilted forward and somewhat downward and the muscles and optic nerve divided, when the eyeball may be pulled right over the lower eyelid so that the divided optic nerve becomes anteriorly placed, and enables the remaining muscles and the conjunctival membrane to be incised at its inferior and infero-lateral sclero-corneal margins.

So much of the conjunctiva and muscles should be left as to form a good stump and as deep a socket as possible, in case an artificial eye may be required to be fixed within the eyelids. Unless these precautions are taken it is impossible to apply and maintain an artificial eye in position].

In the human subject a purse-string suture is put round the conjunctiva which encloses the stump. Bayer recommends this suture in animals in which it is easy to apply.

The cavity of the orbit is cleansed, filled with antiseptic gauze to prevent nervous complications (Blandinières) and the eyelids are united by a few sutures to keep the dressing in place; the dressing should be renewed in three or four days. Then antiseptic injections are continued until there is no more discharge.

Following on the enucleation of the eye, the eyelids turn in as they do in entropion. If it is intended to insert an artificial eye it is well [not to excise more of the conjunctival membrane than is absolutely necessary, and] to watch that the lids are not retracted so far as to interfere with this operation.

[**Total Tarsorrhaphy.** Gray has frequently performed, always with successful results, complete tarsorrhaphy in the cat and dog, with the object of removing an unsightly orbital cavity that only forms a receptacle for dust and dirt and gives rise to a discharge which soils the eyelids. The eyeball, if present, the *whole* of the conjunctival membrane, the lacrimal gland, and the free or mucous margins of the eyelids have to be entirely removed.

His procedure is, first of all, to enucleate the eyeball, the conjunctiva, and the lacrimal gland, and to allow the resulting wound to granulate and to cicatrize. When cicatrisation has become almost completed the free or mucous edges of the eyelids are clipped off by very sharp scissors, and the raw surfaces are brought together by a few sutures and allowed to become adherent, which quickly takes place.

This operation leaves a depression, which may be remedied by Ghisleni's method].

Evisceration or Exenteration of the Eyeball. [*Mules' Operation*]. Enucleation has the disadvantage of leaving the orbit too empty, and of producing an unsightly falling-in of the eyelids. Evisceration or exenteration has been devised with the idea of preventing these inconveniences. This operation seems to have been tried on the horse for the first time by Wardrop with the intention of preventing sympathetic (?) inflammation, and was afterwards applied to man by Barton. Schimmel and Jorge have practised it in the dog in cases of hydrophthalmos.

It consists in removing the anterior part of the globe, emptying its cavity, and keeping the greater part of the shell of the eyeball intact.

Dissect the conjunctiva widely away from the cornea, then with a cataract knife or a bistoury puncture the sclerotic 5 mm. from the sclero-corneal margin and make a circular section of the anterior segment of the globe with the scissors. The vitreous humour and the lens come out, the retina is cut away at the papilla, and the choroid is removed by curetting. The sclerotic is sutured, and above it the conjunctiva, allowing for drainage for some days if necessary.

A large stump is thus obtained, becoming a little reduced with time, but it fills up the orbit much better than that left by enucleation. With the idea of improving the appearance still further Bayer tattooed the surfaces by injecting under the conjunctiva covering the stump a solution of Indian ink.

Bayer also made an attempt at replacing the enucleated eye by a globe-shaped foreign body included in the tissues of the orbit. The attempt was not successful. [These globes may be obtained in various sizes in glass or silver.

Abscission or the excision of the cornea affected with staphyloma is sometimes advisable so as to give a better stump for the artificial eye. It is carried out by passing four or five half-curved needles carrying silk through the eyeball at the sclero-corneal region in front of the recti muscles, the corneal membrane in front of the sutures is cut off, the needles passed through, and the sutures tied. This operation should not be performed when disease exists elsewhere in the eyeball].

Exenteration of the Orbit. This operation, practised in cases of malignant growth in the orbit with the object of, if possible, preventing a recurrence, consists in the removal of all the soft structures within the orbital cavity. To do this the palpebral opening is enlarged inside and outside as far as the rim of the orbit so as to admit of easy access to the cavity. Then with a scalpel the soft structures are cut on a level with the rim of the orbit, separated from the wall of the ocular sheath (periorbital membrane) from its base to the apex. Here the optic nerve and the ophthalmic artery are cut through by scraping, to avoid any hæmorrhage, which, if it occurs, should be arrested by the thermo-cautery. [Some authorities are of opinion that this latter procedure would be disastrous in effects]. The ocular sheath being curetted and cauterised if possible, the orbit is irrigated with sublimate solution, and packed with iodoform gauze; a dressing is then completed by suturing the lids.

Ocular Prothesis. Artificial Eyes. [Percivall mentions that the Board of Ordnance had brought to their notice an

an artificial eye for the horse at the early part of the nineteenth century]. Schmidt, a Bavarian Military Veterinary Surgeon, seems to have been the first to make use of artificial eyes in horse (1853). Since then several operators have used them on animals; Bauer, Hertwig,* Bayer, Trasbot, Böllemann, [Field, Jnr., Walley, and F. Smith †], on the horse; Mouquet and Child in the dog, Schauber in a cat, and Günther in a heifer.

The apparatus which has given the best results in the horse is a spherical vulcanite cup 4.5 cm. in width, 2 cm. in depth, and 2 mm. in thickness, with smooth and well-rounded edges.

It weighs about 10 grammes; its convex face is polished and is marked with a groove representing the pupil.

To place it in position it is first introduced under the upper eyelid and then under the lower. It is not necessary to remove it every day to clean it.

Fig. 142.
Artificial Eye for Horse.

The artificial eye should be placed *in sitû* two to three weeks after the enucleation, or in other words as soon as the stump has healed. The irritation of the new eye, which produces sympathetic ophthalmia in man, is not to be feared in the horse and the other domestic animals.

Mouquet has not had much success with the use of artificial eyes of vulcanite or enamel, but he prefers a small glass eye looking like a collar stud with a very short neck. If removed each day for cleaning they may be worn for years without accident. [William. Field, Jnr., used an artificial eye of horn.‡

General Smith who has paid great attention to the use

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* Hertwig: Magazin für die gesammte Thierheilkunde, 1873, and *Veterinary Journal*, Vol. i, 1875, p. 246.

† F. Smith. Artificial Eyes for Horses, *Quarterly Journal of Veterinary Science in India*, 1884-5.

‡ *Veterinary Journal*, Vol. i,, 1875 p. 235.

of artificial eyes in horses says: "My experience of artificial eyes is wholly in their favour, but they require careful fitting and changing at the first sign of irritation. They *must be removed daily;* at first a good deal of discharge is held up behind them. As to their æsthetic effect, they put life into the face of the horse. They are removed by the reverse process of introduction, lower edge first. A small size should first be worn and a larger fitted later. Before they are inserted they should be lubricated with vaseline. They should not be circular but oval. This facilitates introduction and removal. If the eye is not oval in shape it cannot be readily introduced, but what is far worse it cannot be readily extracted. Equally, it must not be too deep or it is most difficult to remove." General Smith used gutta percha eyes made for each horse, but acting on his suggestion Davidson now manufactures them in celluloid].

Schauber, an ophthalmic surgeon, fitted his cat with enamel eyes prepared for use in man; then, after different attempts, he had some made on the same lines. The cat wore one for seven years. [Artificial eyes for the horse, dog and cat have now become an article of commerce, and are frequently applied in practice. They are so manufactured as to suit the particular requirements of the case].

Ghisleni has practised ocular prothesis in a horse and in two dogs by means of an injection of paraffin wax. The eyeball having been enucleated and the stump cicatrised, blepharraphy (tarsorrhaphy) is performed. Paraffin wax at 40° C. is afterwards injected by the nasal angle between two stitches; 7–15 cc. for the dog, 15–25 cc. for the horse. The solidification of the wax is hastened by the application of cold compresses. Around the foreign body is formed fibrinous exudate, which is soon replaced by connective tissue, which ultimately penetrates the paraffin wax.

Clinica Veterinaria, 1907, pp. 365, 381

CHAPTER XII.

THE ORBIT.

Anatomy.

The orbital cavity, completely osseous in man [and apes], is not so in [the domesticated] animals. In them it communicates widely in the skeleton with the temporal fossa posteriorly; it is only by the intervention of a fibrous membrane called the ocular sheath or periorbitale that it is transformed into a conical-shaped cavity, having its base anteriorly placed. In the horse the bones of the face and of the cranium form the internal wall, the anterior third of the floor, and they only limit the superior and external parts of the orbit with a ring of bone—the orbital arch. It is almost the same in ruminants.

In the domesticated carnivora, and in the pig, the orbital arch is incomplete and is replaced by a very resistant ligament.

In the horse the orbital rim is very thin and prominent, and its edge is very sharp in the supero-internal part. It shows on the face of the lacrimal bone a small tubercle for the insertion of the orbicularis tendon. The base of the orbital process of the frontal bone is pierced by a hole known as the supra-orbital foramen, which gives passage to the artery and nerve of the same name. On the internal wall can be seen the superior opening of the lacrimal canal, slightly spread out into funnel-shape, then immediately behind this is the lacrimal fossa, which lodges the lacrimal sac; on its lower margin the inferior or small oblique muscle is inserted. Above the lacrimal fossa, and at the base of the orbital process there is a slight depression to receive the "pulley" of the superior or great oblique muscle.

The *orbital membrane* or *periorbitale*, formed of a fibro-muscular membrane, has the form of a regular cone in the dog, slightly flattened laterally in the horse; its apex is fixed round the optic foramen and the sphenoidal canal, and its base all round the orbital rim. The sheath not being protected on the outside is thicker, and is here strengthened by an elastic band; it is not so thick on the inside where it

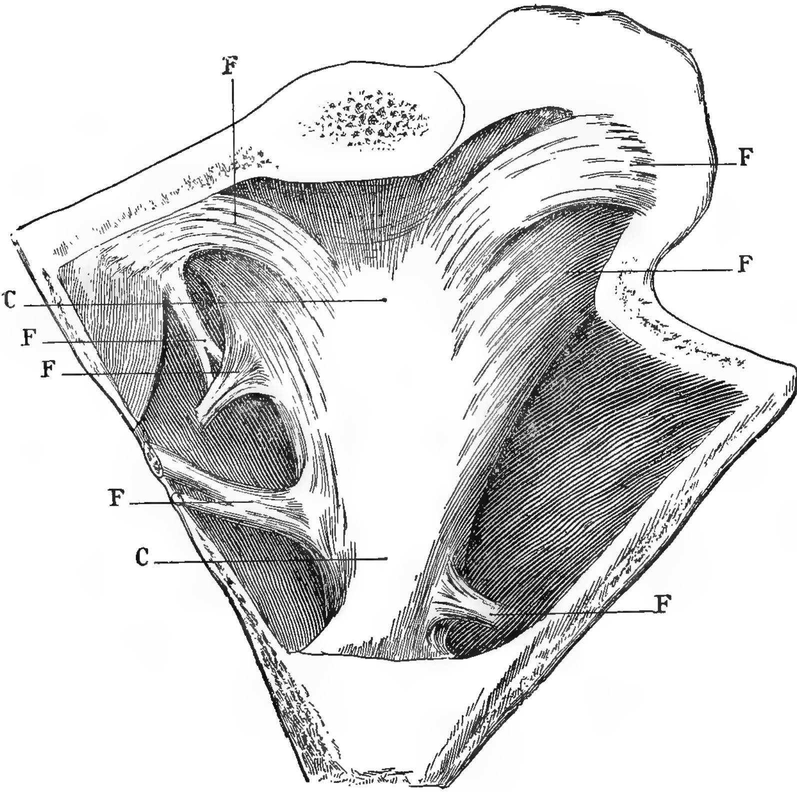

Fig. 143. Orbital Sheath of the Horse.

CC, The orbital sheath. *F*, *F*, *F*, Fascicula of its insertion. *(Encyclop. franç. d'ophtalm.)*

rests on the bony wall. The axis of the orbital sheath is directed forwards, outwards and downwards. (For the direction of the orbit see p. 7).

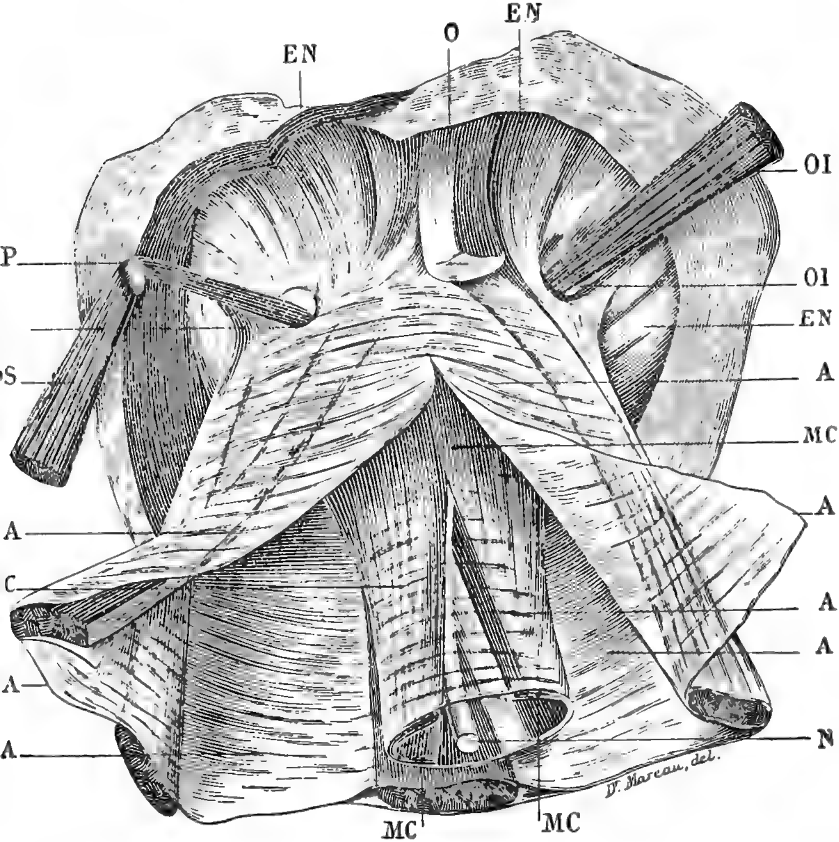

Fig. 144.—Capsule of Tenon of a horse (Motais).

A, *A*, *A*, Sheaths and intermuscular and aponeurotic layers of the recti muscles. *A*, Sheath of the choanoid muscle. *MC*, *EN*, *EN*, A thin strip of the aponeurosis attached to the orbit. *N*, The optic nerve. *OI*, Inferior oblique muscle. *OS*, Superior oblique with its "pulley," *P*. (*Encycl. franç. d'ophtalm.*)

The contents of the orbit are made up of the eyeball, the optic nerve, the motor muscles, the lacrimal gland, the vessels and nerves. These different organs are kept in their respective positions by adipose tissue placed between them and by a system of aponeuroses which has been called the capsule of Tenon.

The *adipose tissue*, spreading between all the organs, forms between the internal and inferior recti muscles a mass called the *fatty cushion of the membrana nictitans.*

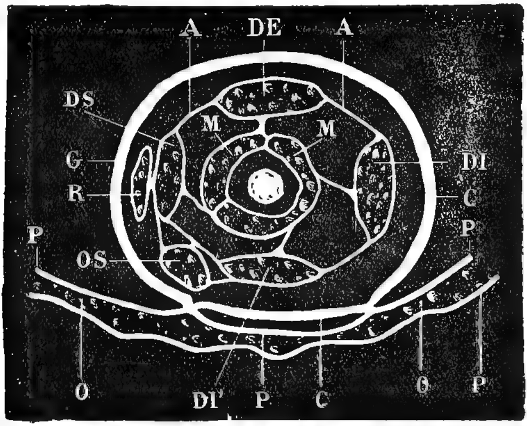

Fig. 145.—Section of the muscles and their aponeuroses at the back of the eyeball of a horse (Motais).
The external surface is placed upwards in the figure.

A, *A*, Intermuscular aponeurosis dividing at the borders of muscles to form a complete sheath for each of them. *C*, *C*, *C*, The orbital sheath. *DE*, External rectus. *DI*, Inferior rectus. *DI'*, Internal rectus. *DS*, Superior rectus. *M*, Retractor oculi. *OO*, Osseous wall. *OS*, Superior oblique. *P*, *P*. Periosteum. *R*, Levator palpebrae superioris. (*Encycl. d'ophtalm.*).

Its anterior edge encloses the fibro-cartilage of the third eyelid. When the posterior rectus or choanoid draws the eyeball to the depth of the orbit, it necessarily pushes the other organs forward, and the pad of fat which is the most

mobile of these pushes before it the "third eyelid" or membrana nictitans.

The *capsule of Tenon*, which has been profoundly studied by Motais in the vertebrate series, presents the following schematic disposition: It is an aponeurosis which binds the muscles together by becoming divided into two layers at their edges to form a separate sheath for each; it also encloses in a sheath all the other organs which it meets—vessels, nerves, and adipose tissue lobules.

Behind, it is inserted into the back of the orbit with the muscles which accompany it; in front it is divided into two leaves, continuous with those of the muscles; one is fixed round the rim of the orbit and to the eyelids; the other is folded back from the insertion into the orbital rim and forms a fibrous shell for the eyeball.

In the dog, as in man, the capsule of Tenon shows ligamentous processes, actual accessory tendons of the recti muscles (Motais).

Blood vessels. "Most of the mammalia possesses two ophthalmic arteries: the internal furnished by the internal carotid; the external, formed by the internal maxillary, a branch of the external carotid; the latter is the larger" (Motais).

They anastomose in the orbit and give rise, the first to the central artery of the retina, the latter to the lacrimal, superciliary and muscular arteries; both help to form the ciliary arteries. The venous blood is poured into the alveolar vein as it passes through the orbital sheath. It must be remembered that this alveolar vein is in communication on one hand with the cavernous venous sinuses of the cranium, and on the other with the facial vein.

The nerves are for the most part motor, some are sensitive. The most important are the *common oculo-motor* (third cranial) which supplies the levator of the upper eyelid, the internal rectus, the inferior rectus and the inferior oblique; the *internal oculo-motor* or the pathetic (fourth pair of cranial) going to the superior oblique; the *external oculo-motor* (sixth cranial)

going to the external and posterior recti. Joined to the common oculo-motor nerve is the ophthalmic ganglion which receives a motor branch from the common oculo-motor, a sensitive branch from the trigeminal, and *sympathetic fibres* from the carotid ganglion. From the ganglion the *ciliary nerves* emerge, and go to the ciliary muscles and the sphincter of the pupil, and a filament from the sympathetic goes to dilate the pupil.

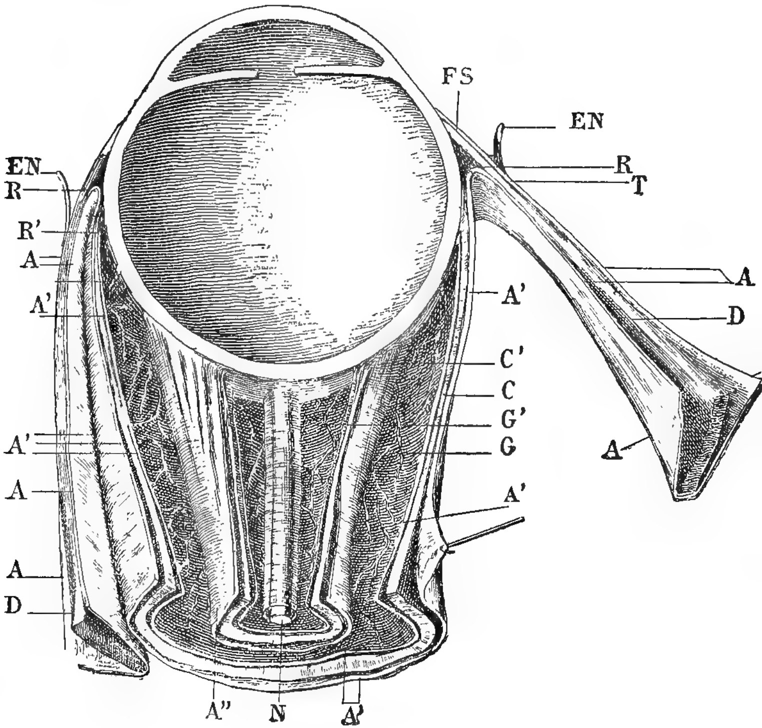

Fig. 146.—Section of the eyeball and of the contents of the orbit behind the eyeball of the ox (Motais).

A, *A*, *A'*, *A'*, Muscular sheaths of the capsule of Tenon. *EN*, Slip inserted into the circumference of the orbit. *R*, *R*, Layer folded back over the eye. (*Encyclop. franç. d'ophtalm.*).

Traumatic Affections of the Orbit. Contusions and wounds are especially frequent in the horse, on account of the nature of the services which he is called upon to perform and of the salience of the rim of the orbit. Caused by injuries from nails or sharp hooks which project in the stable, from sudden stops behind another vehicle, or from pathological, [accidental and surgical] decubitus, they are still more often due to the brutality of attendants, grooms, etc. These are the same for the other animals. [In coal-mines where such injuries are very frequent they are chiefly due to the animals, before they get used to the roadways, running against projecting rock or coal]. They are always accompanied by a more or less painful swelling, resistant or even fluctuating, caused in the latter case by a collection of serum or blood subcutaneously; or if the injury has extended to the bone it may be sub-periosteal, Wounds of the membranous wall do not present any peculiarities except that they may very easily be the starting point of an inflammation of the other parts. Those of the bone may lead to necrosis (Rey). When they are situated in the region of the supraorbital process they may be produced by the bony rim which acts as a sharp instrument.

No special treatment is needed. However, if an opening has to be made it should be done in the direction of the orbit, or in the length of the muscles.

Fractures are especially seen in the horse in the orbital arch, which may then present a solution of continuity right through its substance, as in a long bone, or in its length with the formation and detachment of splinters. These are hardly ever recognised unless they tend to work their way out by leading to the suppuration of a wound inflicted at the same time, or to form an abscess. Solutions of continuity across the orbital arch are recognised by the deformity which they cause in the region, usually a sinking in of the affected part; abnormal mobility and crepitation are often difficult to detect.

Fractures of other regions of the orbit are rare; Revel has seen a case at the edge of the zygomatic process. After a

blow sustained in a tram accident Lanzilloti saw a fracture of the zygomatic (malar) and lacrimal bones, as well as of part of the superior maxilla; as a complication the eye was luxated and free from any adhesions. [Gray saw a fistula over the eyelid of a Bedlington terrier belonging to R. C. Irving. As soon as a sequestered piece of bone from the orbital rim was removed, recovery rapidly took place].

Intervention must take the form of attempts at removing splinters leading to suppuration, or to replace the broken parts if they wound the eye or hinder its movements.

Reduction is, as a rule, possible by the introduction of the fingers of one hand into the superior conjunctival cul-de-sac to lift up the broken ends, whilst those of the other hand are placed on the external surface of the orbital arch. Hendrickx, not being successful by this method, had to trephine the the frontal sinus and place in it a curved steel elevator to raise up the sunken part of the orbital arch.

Inflammation of the Orbit, Tenonitis or Orbital Cellulitis. In consequence of the abundance of fatty cellular tissue, and of the arrangement of the aponeuroses in the orbit, if there is sufficient cause, any inflammation spreads very rapidly, and the products of this inflammation coming together from all sides, but especially towards the entry of the optic nerve and in the direction of the brain, the condition may speedily become a dangerous one.

The inflammation may have its origin externally; fractures, suppuration in the neighbourhood as those seen in strangles (Lindemann), or infected wounds may give rise to it; Robellet, Cadiot and Almy, have seen an acute septicæmia ending fatally, following on wounds of the orbit in the horse. Under the same conditions Leblanc saw a fatal case of meningitis in the ox. [Gray has seen similar cases, occurring in a district notorious for malignant œdema. It is very rare or has never been seen in the experience of certain authorities who have had extensive experience of supraorbital injuries, no doubt due to the care such wounds receive almost as soon as they occur.

Orbital cellulitis is of frequent occurrence in the horse, more especially in certain country districts, where slight injuries to the supra-orbital region are lightly treated or neglected. It is usually fatal after running a very short course. It mostly arises from accidental wounds caused by the animal falling on its head, from wilful blows, or from infection spreading from other parts in the vicinity of the orbital region. It has followed extraction of molars, and Gray has seen it arise from a strangles abscess in the naso-frontal region accompanied by snuffling and terminating in cerebral infection, with tense elevated swellings, the size of an orange, standing above both eye-pits, amaurosis and loss of power of the limbs but no gross lesions in the brain after death. In many cases of the disease arising from supra-orbital injuries there is acute panophthalmitis. Harvey,* of St. Columb, Cornwall, has directed special attention to the medical and surgical importance of the post-orbital region in practice, and as he has faithfully described acute orbital cellulitis as it appears in the majority of cases, his actual words are quoted here in full :

"THE CLINICAL IMPORTANCE OF THE POSTORBITAL REGION.

It is simply intended here to allude to the frequently grave results following wounds, large or small, inflicted in the postorbital region, and to the significance to be attached to puffing or filling of the spaces behind the orbit (temporal fossæ) in certain cases of illness. It may therefore be looked at from both a medical and surgical point of view. When one considers the movements the parts are subjected to during mastication, their unyielding character, and the great variety of tissues adjacent thereto, it is not surprising that serious results often attend comparatively small wounds in the neighbourhood of the orbit. I am of opinion that wounds do as badly if not worse here than in any other part of the body. At any rate I have come across a good number of cases of infective inflammation starting, say, from bruising of the zygomatic process or ridge, or small contused or punctured wounds in the vicinity, and which have nearly always terminated fatally. True such wounds have not come under proper treatment at

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* *Veterinary Record*, Vol. xvi, 1903-1904, pp. 449, 450.

the outset, or when inflicted. Usually contused, small and unimportant looking, they are liable to be treated lightly—if treated at all. In such a case, if the wound is going wrong, the parts in a few days will be swollen and hard, and the wound angry looking. The hollow space behind the orbit will be bulging more or less, and there is general systemic disturbance. The swelling then extends rapidly over the face and towards the base of the ear, and the opposite orbit becomes similarly involved. The tissues around the original wound break, and the swelling assumes a boggy character. Such a case lasts from two to four days; death sooner or later closing the scene. In such a case as we have indicated above, what is to be done? Continuous warm fomentations are useless to check the morbid processes going on in the wound. They may relieve pain, but they have no other effect, except that the owner may feel that something is being done for the animal. Applications to the wound itself do not cut short the case, and have very little effect. Any curative measures to be useful must be prompt, and it is impossible to open or scarify the part unless the head is fixed. Accordingly it was decided that when the next case occurred the animal should be at once cast, chloroformed, and the parts freely opened. The result was not at all satisfactory. The notes of the case are as follows:

Case I.—A six-year-old grey mare, seen to have a small punctured wound in the centre of the zygomatic process on the left side. No importance was attached to it, and the mare was kept at work. On the third morning there was a good deal of swelling around and behind the orbit, which increased during the day. I saw her at 4 p.m. The following morning the mare was cast on a soft bed and an attempt made to lay open the parts, the swelling having spread considerably during the night. Little could be done, however, in relieving tension on exposing the diseased tissues, and death occurred forty-eight hours later.

Case II.—An aged grey horse got hung by his halter, and the parts were damaged rather badly. I saw the case ten days later, when the eyeball was being pushed out of its socket owing to the swelling behind. The eye was at once removed and the parts opened as freely as possible, but death occurred on the following day.

One could recapitulate other cases met with in the course of practice extending over several years, but their history, course and termination would be almost similar to those given above. I will therefore now allude to another condition, which consists in filling-up or bulging of both temporal fossæ in certain cases of illness, and which cannot be directly associated with any local wound infection. Such swellings

are usually symmetrical from the start, generally indicate some serious blood contamination, and are a grave feature in giving a prognosis. They are seen in anthrax, and in various other septicæmias, and frequently give the first indication of danger.

Case III.—A mare, very reduced in condition from dental trouble involving the posterior lower molars. The teeth were accordingly levelled with a Thomson's shears, and she then began to feed ravenously. Thirty-six hours later she was looking comfortable and still feeding well. It was noted that the temporal fossæ, formerly very marked, were filled up and bulging. Otherwise nothing seemed amiss. The mare died the following day. At the post-mortem there was found gangrene of the socket of one of the teeth which had been operated on. The necrotic tissue was very limited in extent, and there was scarcely any surrounding swelling. The teeth, or the parts removed, are before you, and it will be noticed that one broke off much below where it was gripped by the shears. It is from the necrotic side.

Case IV.—A bay mare, four years old, was found off her food, and looking very dull. The owner saw that the parts behind the eyes were rather prominent. The mare was walked in a distance of six miles. The temperature was 104 F., respirations hurried, pulse frequent and small, and depression marked. There was bulging of the temporal fossæ, but no other swellings were noticed. The mare was given stimulants and intestinal antiseptics, and kept very quiet. Death took place twelve hours later. The cause of the illness was unknown. It was not a case of anthrax.

These few cases which I have given—and I might quote others, point I think very clearly that whenever we have filling or bulging of the parts under discussion the case is usually of a very grave character and demands the most searching examination of the patient on the part of the practitioner."

In *man* this region is also considered of very great importance, and in him acute cellulitis is a very serious malady and frequently ends in death. In the *dog* acute orbital cellulitis is not rare, but it usually results in suppuration, which is speedily followed by recovery. Chronic orbital cellulitis and chronic abscess are not rarely associated with necrosis of the periosteum or bone, or the resulting exfoliation of the necrosed bone or a foreign body which, when removed, rapidly ends in recovery. They are, however, usually due to tuberculosis, hetereotopic teeth, carcinoma, etc.].

Foreign bodies coming from the mouth or from without through the skin may lead to the same result: Lapoussée and Merle have found, in cases of inflammation of the orbital contents, spikelets and barley awns which, in consequence of the movements of the jaws, had found their way from the mouth to the orbit, leaving a fistulous track behind them. Schwenk found the sting of a bee in one case in a dog (?).

Rhinitis and collections of pus (empyema) in the air-sinuses may also spread to the orbit, as in a case seen by Lange in a dog.

Orbital inflammation may also to some extent be metastatic and internal in origin. In strangles Nöhr and Veit have seen abscesses, and the last-named author saw the purulent infection propagated along the optic nerve as far as the meninges. Schindelka, Blin, and Ciattoni have noticed intraorbital exudations in purpura hæmorrhagica in the horse.

A case may be mentioned in which six members of one family were attacked with tenonitis, and showed, besides the local symptoms, signs of general infection; in this case Zelinski, Nencki, and Karpinski accused distemper of being the cause. A dog which had contracted the disease naturally was found to have a staphylococcus in the conjunctival cul-de-sac, and this being inoculated into the same position in other dogs, the authors were able to reproduce a condition exactly similar to distemper in dogs and to tenonitis in man.

Symptoms. Inflammation of the tissues of the orbit usually causes general symptoms, and can be recognised locally by the filling up of the "eye-pit"; this swelling, if it is not connected with the exterior by the causal wound, may end in the formation of fistulæ which give exit to a sanguinolent, purulent discharge, sometimes fœtid and containing foreign bodies, as in the cases mentioned by Lapoussée and Merle. The eyelids are swollen, especially the superior; the conjunctiva is œdematous and chemotic; there is always more or less exophthalmos, the protrusion being partly reducible. Ophthalmoscopic examination sometimes reveals the presence of deep-seated lesions: stasis of the papilla (Bayer, Möller),

anæmia of the papilla leading to atrophy (Schindelka). The sight is more or less diminished from time to time on account of the stretching of the optic nerve.

Treatment. This consists in giving vent to the pus as soon as its presence is revealed. In animals this presents no difficulty since the orbit is not entirely closed in behind by bone. If there are fistulæ they must be opened widely in the direction of the axis of the orbital sheath to avoid section of the muscles; they must then be drained and irrigated with solutions of sublimate or chloride of zinc if the discharge is fœtid. Cooling lotions and blisters may be used to combat the inflammatory symptoms. In threatened acute malignant cases, antistreptococcal, antistaphylococcal, etc., sera should be tried.

Tumours of the Orbit. These may be developed locally or extend from the surrounding parts such as the cranium (Hébrant), nasal cavities (Petit), maxillary and frontal sinuses (Banvillet), the retro-pharyngeal glands (Besnoit), or the external surfaee of the orbital rim. Oreste and Falconio observed an osteoma on the external face of the frontal bone of a dog; it was so placed that it compressed the eye from before backwards.

They differ greatly in nature. Exostoses are frequent in the ox (Leblanc). According to Cadiot and Almy "Dentigerous cysts (heterotopic teeth) are often taken for actual exostoses as they are commonly implanted in the walls of the orbit or in the immediate neighbourhood." Gurlt and Voigtlander have each recorded a similar case. Fibromata have been recognised on the orbital arch in the horse (Erler and Voigtlander), and in the cow (Werner). Berlin and Hoffmann have extirpated lipomata from the orbit of a horse; Kampmann and Werner have encountered it in the ox. Sarcomata, melano-sarcomata, osteo-sarcomata, and lymphosarcomata have been met with by Möller, Hébrant, and Petit in the dog; Emmerich, and Besnoit in the ox; Schütz, Anacker, and Bayer in the horse. Möller operated on a sarcoma in a horse which had almost entirely destroyed the whole of the orbit. Cook has described a similar case occurring in a cow.

Reeser and Bayer have seen others in the dog and horse. Actinomycosis destroying the bones of the head, and penetrating the sinuses, and the orbit, has been reported in the horse by Rousselot. [Tuberculosis and adenomata are somewhat frequently observed within the orbit in the dog. In the bird, the parrot tribe in particular, tuberculous swellings are often seen in the orbital cavity].

Parasitic cysts have been seen: *cœnurus serialis* in the orbit of a rabbit (Lucet, Byerley). In the horse Kirkmann and Heincke have found hydatid cysts. In Heincke's case occurring in a foal a fortnight old and in which the cysts coexisted with microphthalmos, it seems likely that if it had been microscopically examined it would have been found to have been a congenital cyst due to some anomaly of development of the eyeball, several cases of which have been studied and described by Keil in the *Berliner Tier. Wochenschr.* 1905 and 1906.

Symptoms. Until the tumour has acquired a certain size it has no effect on the eyeball, and if it has developed out of sight its presence will not be suspected.

When it reaches a certain size it pushes the eyeball in front of it, producing exophthalmos which is usually accompanied by strabismus in one direction or the other; sometimes the eye is pressed back into the orbit and undergoes atrophy (Ketterer). At the same time a swelling of the eyelids is produced with an abnormal vascularity of the conjunctiva, the eye has a fixed appearance due to its movements being hindered, and there is some visual disturbance caused by alterations in the deep membranes of the eye such as venous stasis, œdema, hæmorrhages, detachment of the retina, etc., all of which symptoms were recognised by Nicolas and Fromaget in a cat having an orbital tumour. At this stage the *diagnosis* is helped by the deformity of the surrounding parts, the irreducibility of the exophthalmos, palpation of the eye-pit, and also digital examination of the conjunctival cul-de-sac in the larger animals.

Sooner or later the tumour shows itself outside the orbit and then diagnosis is certain.

The *prognosis* of these orbital tumours is always a grave one, both from the point of view of the loss of vision from pressure which they exert on the eye or on the optic nerve, or on the muscles (causing mechanical or paralytic deviations); or from the recurrent character of the growth when it is removed and the possibility of the animal losing its life from the malignant invading tumour.

Treatment consists in removal, except in the case of a congenital cyst causing atrophy of the eye; it is sometimes possible to remove the tumour and leave the eyeball (Reeser). As a rule the eye has to be sacrificed together with its appendages and evisceration of the orbit has to be performed. If the tumour recurs or is inoperable the animal should be sent to the butcher if suitable or otherwise disposed of.

CHAPTER XIII.

THE EYELIDS.

Anatomy.

The eyelids, upper and lower, are two cutaneous folds of skin, movable in a vertical direction, closing the orbital opening in front of the eyeball which they are destined to protect. They are attached to the circumference of the orbit. The superior is much the larger and more mobile in the mammalia.

Their external faces are covered with fine skin and when the lids are closed are convex in all directions, and are very convex in an animal having a prominent eyeball. When they are open, however, the upper lid forms folds parallel to the ciliary body and the orbital arch while the lower remains smooth. The part of their internal faces which is in contact with the eyeball is covered with conjunctiva—the palpebral conjunctiva. By their free edges the eyelids close the *palpebral fissure.* This opening has the form of a buttonhole (the superior concavity being more marked than the inferior) the temporal commissure of which is triangular and slightly rounded; the nasal commissure has the form of an arc made up of three curves which lodge the caruncula lacrimalis. When the eyelids are normally open in the horse the upper lid hangs a few millimetres over the cornea whilst the lower is in close apposition with it. The palpebral fissure in birds is, when open, quite circular.

The scleral or sclerotic can thus only be seen near the commissures; but in the horse, in the ox and sheep, and in many dogs, the circumcorneal conjunctiva being pigmented, the whole of the visible part of the eyeball appears brown. It is only exceptionally, in certain abnormal cases of albinism,

or when the animal voluntarily dilates its palpebral opening, as some vicious horses do when they are about to do mischief, that the white of the sclerotic (œil cerclé) is visible. This gives the horse in particular a peculiar expression which there is no reason to associate with anything unfavourable to good sight, as has been asserted.

The margins of the eyelids, slightly rounded and normally pigmented, show a varying thickness. The superior is as a rule the thicker of the two. In either lid the thickness is increased at the points at which the eyelashes are implanted. The lids are thinnest at the temporal canthus; here they are so thin that they hardly project at all from the eyeball, to which they are closely applied.

On the outside of the palpebral borders the eyelashes or cilia are inserted; in the horse, and in ruminants, in three or four rows on the upper and one on the lower lid, but only in the middle region of both lids. The upper eyelashes are long, close, thick and stiff, and in the horse form a kind of lattice work; the lower are short, thin, few in number, and scarcely visible.

Inside the palpebral margin a line of dot-like openings is quite visible in the horse, representing the puncta of the canals of the *Meibomian* or *tarsal glands*. These glands form on the internal face of each eyelid a quite regular row of small lines perpendicular to the free edge, yellowish-white in colour and slightly salient under the mucous membrane. They are larger in the upper than in the lower lid, and exactly represent the height of the *tarsal cartilages*. On a level with the angle formed by the meeting of the arcs of the nasal commissure, and on the mucous face of the borders of the lids, the fine slit-like openings (puncta lacrimalia) of the lacrimal canaliculi are to be seen.

Closure of the palpebral opening in the mammalia is almost entirely effected by the lowering of the upper lid, the inferior only being raised a few millimetres. This movement, directed by the orbicularis of the eyelids, and probably to a certain extent also by the unstriped muscle of Müller, takes place in

such a way that the fissure is closed from the temporal towards the nasal canthus, thus driving the tears towards the lacrimal openings or puncta. Opening of the palpebral fissure is brought about by the contraction of the levator palpebræ superioris and the corrugator supercilii in the upper lid, the malaris in the lower lid, and by the relaxation of the orbicularis. The unstriped muscles of Müller (*musculus tarsalis superior* and *musculus tarsalis inferior*) in the eyelids also play some part in this function. When the eyelids are closed, their free surfaces are approximated to each other with perfect accuracy, so that with the assistance of the lubricating secretion of the Meibomian glands they are capable of keeping the lacrimal fluid in, and hence are watertight.

Winking is a reflex action excited by a sense of dryness of the eyes, or by external stimuli such as dust, flies, touch, foreign bodies, etc. Its effect is (1) to cover the surface of the eyeball with a uniform layer of lacrimal fluid in order to prevent desiccation; (2) to remove dust and other foreign material from the eye; and (3) finally, to drive the lacrimal fluid towards the inner angles and into the puncta. This reflex action is effected by the trigeminus. In man this function may also be a voluntary one.

Structure. The framework of each eyelid is formed of two layers of close, dense, fibrous tissue called the tarsi. They are situated near the free border of the lids, and give them a rigidity which prevents them from wrinkling under the influence of contractions of the orbicularis. These tarsal plates are less developed in the domesticated animals than in man and in the monkey.

In the horse the superior tarsus, measuring about 8 mm. in height, is slightly broader than the inferior, which is only about 4 or 5 mm. (*See* Fig. 147). The Meibomian or tarsal glands are hollowed out of the thickness of these tarsal cartilages; they are acinous glands, in fact, nothing but large sebaceous glands, the greasy products of which help to facilitate the movements of the eyelids over the eyes, to prevent the overflow of tears over the free borders of the

lids, and to protect them from the irritant action of the tears. They are arranged in a series of fine lines, close together, and running in a perpendicular direction to the free margin of each lid. In the upper lid they number 45–50, in the lower 30–35. Each consists of a tubular duct surrounded by numerous alveoli. These glands are easily seen when the conjunctiva is not too densely pigmented. In the ox they are more deeply embedded and therefore not so perceptible. In the pig they are short and curved. From the excentric borders of the tarsal plates some fibrous bands

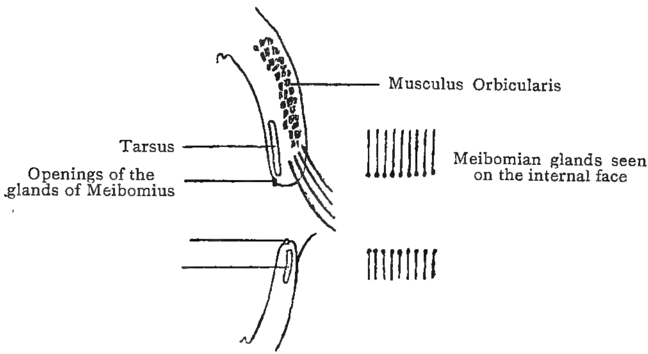


Fig. 147. Section of the Eyelids of the Horse (natural size).

go to be attached to the circumference of the orbit. On the external face of these bands the circular fibres of the orbicularis muscle of the eyelids are found; they are much more developed in the upper than in the lower lid. They are united near the commissures to small tendons called the palpebral ligaments, which attach them to the orbit. At the nasal or internal commissure a bundle of fibres becomes detached from this muscle and pass behind the lacrimal sac, and is known as Horner's muscle. The tarsus gives insertion to a layer of unstriped muscle, known as Müller's or the tarsal muscle. In the upper lid its fibres arise between the fibres of the levator. In the lower lid the fibres are found on the under side of the inferior rectus.

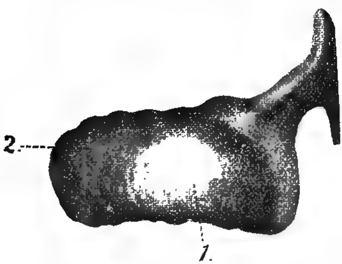
In the *horse* the orbicularis is directly covered by a cutaneous investment without the interposition of fatty or loose connective tissue, and this renders the skin not very mobile, and the region is not very convenient for certain plastic operations (Duquet). On the internal face of the superior fibrous band, in all mammalia except the Cetaceæ, the expanded or fan-shaped tendon of the levator palpebrae superioris is attached to the tarsus.

In *birds* the lower lid is more developed and more mobile than the upper, and it plays the same part as the upper does in the mammalia. In birds, as in the reptiles, there is a depressor of the lower eyelid, more powerful than the levator, and inserted into the depth of the orbit. In most birds only the lower lid is movable and frequently contains a rather large saucer-shaped cartilage, which is large in Ratitæ, Birds of Prey, and Gallinæ ; but is absent in parrots. The Meibomian glands are absent and their place is taken by a pair of Harderian glands which pour their slimy secretion out below the membrana nictitans at the inner corner of the eye. They are yellowish white, always placed within the orbit upon the median and upper surface of the eyeball, and are of an irregular, often considerable size. In some birds the *nasal glands* extend into the orbital cavity or are placed on the orbital margin. In certain birds small feathers take the place of the eyelashes and of tactile hairs, while in others, *e.g.*, the ostrich and certain parrots, the eyelids are provided with very fine eyelashes (rudimentary feathers without barbs) resembling in appearance those in mammalia. According to Kalt the eyelids of some parrots and many other birds are absolutely bare.

The **Membrana Nictitans,** winking, or third eyelid, commonly termed the haw, is situated in the nasal angle of the eye. In the horse its base is formed of a hatchet-shaped cartilage, the thin broad part being anterior, and the thick and narrow head or base is situated deeper in the orbit. This hyaline cartilage is also curved to remain in contact with the eye, and is covered in about two-thirds of its extent by

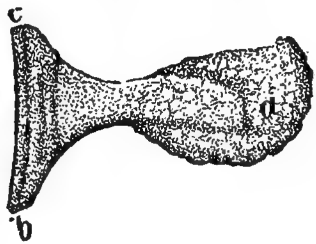
a fold of conjunctiva which increases its surface. In the other animals it is not so well developed. The thin margin of the third eyelid, generally pigmented in some of the domestic animals, is free, and sweeps over the surface of the cornea, whilst its thickened base is in contact with a pad of fat which regulates the passive movements of the membrana nictitans. In a state of rest, therefore, the third eyelid forms two culs-de-sac, one between it and the eyeball and the other between it and the internal wall of the orbit.

On the internal face of the membrana nictitans under the conjunctival mucous membrane is found the gland of Harder, which has been previously mentioned. (*Vide* p. 112). This gland resembles the lacrimal gland in structure. In the ox it is very large, being an inch or more in length; it



Cartilage of the Membrana Nictitans (Horse).

1, Gland of Harder; 2, adipose tissue surrounding deep part of cartilage. (Ellenberger).



Cartilage of the Membrana Nictitans (Dog), external surface.

a, Gland of Harder; *b*, external angle, and *c*, internal angle of cartilage. Magnified × 2. (Ellenberger and Baum).

may be divided into two parts, the deeper being pink and consisting of loose lobules, but the much larger superficial part is more compact. It has two large and several smaller excretory ducts. In the pig, in addition to the gland which surrounds the deep part of the cartilage, there is a deeper gland of Harder, which is surrounded by a distinct capsule and a blood sinus. It is brownish or brownish-grey in colour, elliptical in outline, and about an inch in length. It is situated deeply below the attachment of the inferior oblique.

The membrana nictitans is well developed in ruminants, a little less so in the dog, [still less so in the cat. Under normal conditions it is, when at rest, not very perceptible in most of the domestic animals, excepting certain breeds of dogs such as the bloodhound, Newfoundland, St. Bernard; but in certain diseases of the eye or of the nervous system it covers the greater portion of the anterior surface of the eyeball. In the class of dog just mentioned the membrana nictitans is much better developed than in those breeds having tense eyelids which well cover the circumference of the eyeball or rather the scleral membrane of it]. In birds it may cover the whole of the eye; its movements are active and controlled by two muscles, the square and pyramidal muscles [*(quadratus nictitantis* and *pyramidalis nictitantis)*. It is transparent or translucent in birds and said to be the same in reindeer*].

The *caruncula lacrimalis* is a small rounded or slightly pear-shaped body, situated in the nasal angle of the eyelids. By its pigmentation, its hairs, and its follicles, it exactly resembles the surrounding skin, of which it is only a continuation. In the sheep there is an *infraorbital* or *lacrimal pouch* in front of the nasal angle of the eye. It is an invagination of about half-an-inch in depth of the skin. It contains follicles in which compound sebaceous glands open, and also coil glands.

Vessels and Nerves of the Eyelids. The lids are fairly vascular, the blood coming from different sides and returning partly by the lacrimal vein and partly by the angular vein.

A branch of the facial (7th) supplies the orbicularis, corrugator supercilii and malaris, whilst the levator of the upper lid is innervated by the common oculo-motor (3rd). Müller's unstriped muscle of the eyelids is supplied by the sympathetic.

Dermatosis and Cutaneous Lesions. *Eczema* has been observed in all the domesticated animals by Leblanc (1824). Some kinds of tetter, says he, "are inclined to affect certain species. The horse, ass, mule, and sheep most often show the furfuraceous tetter, the ox especially at two or three years

* [It is said this animal projects it over the eyeball at pleasure during the violent snowstorms or the glistening of the snow so common in its natural haunts].

of age is subject to a pustular variety with the formation of crusts which generally disappear in the winter and reappear in the spring. The dog is subject to acute and farinaceous tetters and the cat to a squamous form." Nicolas has only had one opportunity of observing a horse in which the eyelids were scaly. There was no redness, no swelling, and the affected skin showed only at its surface small yellowish efflorescent concretions, the size of a pin's head, and a number of small bran-like scales on the skin and between the eyelashes. There was a slight photophobia and frequent blinking of the eyelids.

Eczema of the eyelids is very common in the dog. It usually causes the hairs to fall out, leaving the skin bare. Loss of hair without any eruption is also often witnessed. It is, however, sometimes associated with the lacrimation of simple conjunctivitis. Both these conditions also occur in the cat. Eczema of the eyelids is often accompanied by eczema of the middle ear and vascular keratitis; also with recurrent generalized eczema. To these affections of the eyelids, with loss of hair, the term blepharitis is applied, but quite erroneously.

The general condition of the animal is to be treated, and to cure the eczema itself, if necessary an ointment of oxide of zinc, yellow oxide of mercury, calomel, or of white precipitate may be used in 1–2 per cent. Dilute mercurial ointment gives satisfactory results in rebellious cases.

Under the name of eczema of the eyelids Trasbot has described what are really the lesions of erythema on the lower eyelid in the neighbourhood (by preference) of the internal angle of the eye caused by the flow of tears in animals suffering from catarrh or acute conjunctivitis, keratitis, entropion, ectropion, or any affection of the lacrimal passages. As has been mentioned, this softening of the epidermis and depilation of the skin towards the nasal angle of the eye is symptomatic of periodic ophthalmia. This erythema needs no other treatment than that of the cause.

Mange affecting the eyelids is not rare in the dog, more

particularly the *follicular form*. It may commence on the lids, particularly on the free margin, and be transferred to other parts of the body, *e.g.*, to the inside of the paws from the animal rubbing the eyes. The lids are swollen, or rather the skin is thickened, and very soon crusts are formed, and then wounds which eventually lead to entropion, sometimes to ectropion.

Varieties of the *demodex folliculorum** are found in the glands of Meibomius and in other anatomical parts of the eyelids alone or when other regions of the surface of the skin in the horse, ox, sheep, goat, pig, rabbit, marmot, dog, cat or other species, are also affected. It is a much more common infestation than is generally allowed, and has been observed in an enzoötic as well as in an isolated form in different parts of Europe, Asia, Africa, and of the New World. Although the presence of this parasite does not always produce palpable lesions, it generally gives rise to nodules or pustules, varying in size from a pin's head to that of a filbert, commingled with serum, pus, or red blood-corpuscles. It may at times appear in association with other parasitic acari.

When it occurs in the dry nodular or scaly form the eyelids should be well-dressed with an application of iodine 1 part in combination with 10 parts or more of oleic acid. A dilute ointment composed of 1 part of strong mercurial ointment and 4 or 5 parts of lard, lanoline or vaseline, is also a very useful agent. In the case of the acneiform abscesses or pustules it is advisable to puncture them and evacuate their contents, afterwards washing out their cavities with biniodide or bichloride of mercury (1 : 1000–500) solution.

In man, in whom it is constantly present in the follicles and glands of Meibomius (Raehlmann), it sometimes causes a parasitic blepharitis with formation of a secretion resembling honey, but not forming any crusts. Raehlmann, in these cases, uses an ointment containing one part of balsam of Peru to three of lanoline.

* A. Martin. La gale démodécique des herbivores, etc. *Revue Vétérinaire*, Juin et Juillet, 1913, pp. 321-389.

Sarcoptic Mange may also be seen on the eyelids, especially in the dog, cat, rabbit and bird.

Ringworm is frequently seen affecting the eyelids in all species but mostly in the ox and cat.

Other parasites capable of causing an irritation of the skin are met with in the eyelids: *Ixodes ricinus* may be hidden in the eyelashes; *hypoderma bovis* deposits its eggs in the subcutaneous connective tissue; the harvest bug or red mite [*Trombidium holosericeum*]; lastly, flies, bees, wasps and ants, whose stings may cause vesicular œdema of the eyelids. Möller reports that according to statistics of the Prussian Army the *tabanus pluvialis* caused the formation of large vesicles showing the sting in their centres; they affected a large number of troop horses, causing œdema of the conjunctiva and a muco-purulent discharge. The same vesicles were found in other parts of the body.

[According to General Smith, in hot countries flies irritate the eyes of horses, and the subsequent rubbing causes œdema, which may be permanent, with eversion of the lids. Eye-fringes should be used as a precaution.

For the *treatment* of sarcoptic mange or ringworm affecting the eyelids, nothing is superior to a weak ointment of unguentum hydrargyri. Stavesacre ointment or the expressed oil is very efficacious in cases of sarcoptic mange or lice. For the removal of ticks, the harvest bug, or other such-like parasites, a dressing of kerosine oil is very satisfactory. For the œdema caused by stings of wasps, bees and flies, repeated applications of lead and opium lotion, vinegar, or even cold water, give good results. A hypodermic injection of cocaine and adrenaline gives immediate relief to pain.

Œdema of the Eyelids is often witnessed in horses suffering from influenza (pink-eye) and purpura hæmorrhagica; in cattle and sheep from blackquarter, anthrax, an urticaria-like malady of unknown origin, in strongylosis, distomatosis, and traumatic pericarditis; in cats, dogs and ferrets, from distemper; and in birds from diphtheria. It is also seen in the horse, ox and dog, in urticaria, and in all species in

injuries to, or an abscess or foreign body in the depths of the eyelids, in the orbital cavity or surrounding tissues; or in malignant œdema. It is furthermore observed in certain fractures in the regions surrounding the orbit, and in stings from wasps, bees, flies, gnats, etc. It is frequently accompanied by extensive swelling of the conjunctiva, which becomes heightened in colour and usually projects from the palpebral fissure, more or less covering the front of the eyeball and hiding it from view.

Treatment consists in removing the cause, if possible; hot fomentations and mild soothing astringents. In the cat, in which it usually attacks one eye only, it generally disappears as the disease of which it is mostly a manifestation, abates. In certain cases, however, it persists for two, three or more weeks, and gives the animal an unsightly appearance. Under such circumstances instillations of adrenaline and cocaine or other mild astringents are then indicated. On no account should strong astringents, caustics or scarifications be adopted, as they most assuredly will aggravate the condition. Tonics and nutritious food should be given, and time allowed for the abnormal condition to disappear. Continued pressure of the swollen conjunctiva on the eyeball for a long period often causes perforative keratitis, and afterwards subsidence of the swollen parts.

Emphysema of the Eyelids is occasionally seen in wound and other microbial infections in the vicinity of the eyes, or in some cases of fracture of the bony coverings of the air-sinuses of the head; it is also sometimes seen in penetrating wounds of the air-sacs, trachea, and skin. In reality, the causes are very similar to those of œdema, with which it frequently co-exists, or may precede or follow.

An Abscess in the Eyelids is not rarely encountered in the horse, dog and cat. In the horse it is generally due to strangles, injuries, or foreign bodies, and in the dog and cat to blows, scratches, bites, foreign bodies, etc.

Treatment consists in opening the abscess early and irrigating the resulting sac repeatedly in order to prevent sup-

puration extending to the interior of the orbital sheath, or meningitis. The abscess should be freely incised].

Ulceration of the Eyelids. Besides ulcerations arising from traumatisms, some cases of ulcers due to specific causes have been reported. Krajewski saw a horse affected with glanders show the first signs in an ulceration of the Meibomian glands, and Petit has described a remarkable case in a cat of tubercular ulceration of the face of a cat which destroyed the eyelids (Fig. 148).

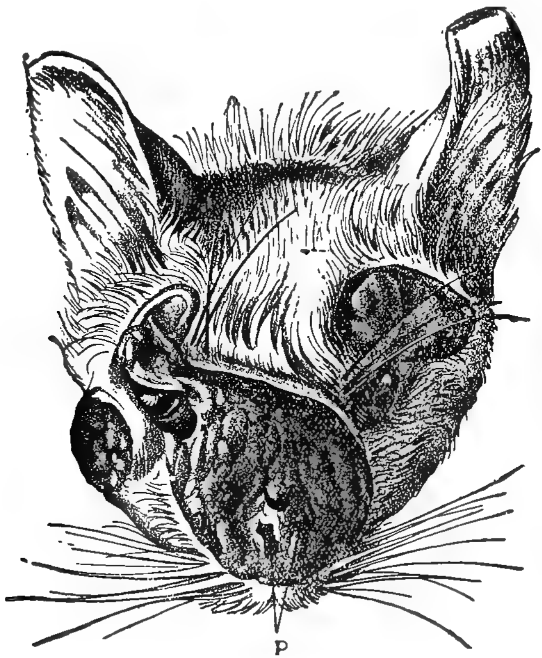


Fig. 148. Tuberculous ulcerations of the face and of the eyelids in the cat (Petit).

[In epizoötic lymphangitis the eyelids with or without the conjunctiva often become the seat of a specific (cryptococcal) ulceration. In a good many instances, however, the conjunctiva is alone affected.

In the dog and cat the irritation set up by the muco-purulent discharge from the conjunctival sac during some severe catarrhal forms of distemper often causes ulceration of the free margin and outer surface of the eyelids, which frequently bleed on the slightest touch. For such a condition repeated inunctions with boracic or zinc ointment, applications of lead and opium lotion, or dustings with zinc oxide and starch or kaolin, keep in check the running on to deep ulceration of excoriated surfaces until the underlying disease has expended itself and the general health improved, when the cause of the irritation usually disappears.

In the dog, one sometimes observes a *chronic recurrent herpetic eruption* with subsequent ulceration due to rubbing the parts, on the free margin and outer surfaces of eyelids, and extending down to the nose. It follows the course of the distribution of the trigeminal nerve, and resembles in many particulars *herpes zoster*. After a short period of quiescence it returns with great irritation, the animal rubbing the parts raw in a very short time. Shiny scar tissue replaces the destroyed skin. It occurs in animals apparently otherwise healthy. No treatment seems to give any permanent benefit. The disease may recur from time to time, and its course extends the duration of the animal's life.

Ulcerations of the eyelids not infrequently arise from more or less deep abrasions of the skin due to contusions or injuries in accidental, surgical or pathological decubitus. In the *rabbit* and *hare* the eyelids are sometimes totally destroyed by the necrotic process set up by the *bacillus necrophorus*, which often prevails as an enzoötic. In *birds* warty or granular ulcerations are seen on the eyelids in epitheliosis (pigeon-pox, chicken-pox).

Epitheliosis or Molluscum Contagiosum in Birds. This is a contagious disease of poultry, geese, pigeons and other birds, due to an invisible virus, and characterised by small nodules varying in size from a maw-seed, to a hemp-seed or even to a pea, covered with dirty greyish, yellowish or brownish crusts, and scattered over various parts of the

body, particularly the angles of the eyelids, the vicinity of the ears, comb, wattles, throat, neck, outer surface of wings, under surface of wings, and around the cloaca.

When the tumours affect the eyelids, they give them a nodular and swollen appearance. The eyelids become closed, the conjunctival membrane protrudes outwards and undergoes a catarrhal inflammation and afterwards gets covered with crusts. Eventually purulent conjunctivitis sets in and the sclera and cornea become inflamed. Finally the whole eyeball is attacked and in the end the sight is destroyed. In pigeons the nodules often cover the entire skin of the eyelids and project over the eyeball like so many cauliflower excrescences. It is a widely accepted view that the virus of epitheliosis is identical with that of avian diphtheria and that the same virus will produce both diseases. In other words epitheliosis and avian diphtheria are one disease with two different manifestations.

Treatment consists in painting the tumours with tincture of iodine or the glycerole of iodine with carbolic acid].

Ciliary or Marginal Blepharitis. Inflammation of the eyelids, or blepharitis, may be the result of a number of causes irritating either the skin or the conjunctiva. But, as such, it has no other interest than as a secondary affection accompanying other symptoms which attract most of the attention. This is not the case with the condition known as marginal or ciliary blepharitis in man. This is a typical affection, characterised by redness, smarting, tumefaction, desquamation of epithelium, and there may even be crusts formed; the eyelashes are shed, and small ulcers may form at their bases, which attract all the attention in spite of the surrounding symptoms.

The etiology is also peculiar in that besides the local and external cause, usually secondary, a scrofulous or lymphatic temperament of the subject plays the chief part.

There is some doubt as to whether anything like this affection, of which the foregoing remarks will serve as a description, exists in the domesticated animals. Möller makes no

mention of it, and Vachetta quotes Leclainche, according to whom "it is frequently seen in the dog, during and after distemper, and also in some very highly-inbred breeds." It is almost always allied to a tendency to rickets and lymphatism. As symptoms "the borders of the eyelids are swollen and the eyelashes are stuck together by a very adherent yellowish or grey, more or less desiccated, material," which may cause them to fall out if the disease lasts for any considerable time. According to Gray's experience primary ciliary blepharitis, as seen in man, does not exist in animals.

[**Hordeolum or Stye.** There are two kinds of styes, an external and an internal. An *external stye* is the result of suppurative inflammation of one of Zeiss's glands at the free margin of the lid. An *internal stye* consists in suppurative inflammation of one of the Meibomian glands. It is much larger than, although otherwise similar in appearance to, the external stye.

Styes are very common in man, but very rare in animals. According to Fröhner they occur in the dog].

Traumatisms of the Eyelids. Wounds may involve only the free margins of the lids or a more or less large part of their whole extent. Lacerations of the free edges, common in troop horses, are most often situated in the upper lid, and are often due to bites. In the horse in coal-mines such wounds are often caused by running against projecting rock. A frequent cause is a horse putting his head through a window after breaking the glass. In the cat and dog similar wounds of the eyelids are chiefly due to fighting. They are usually parallel to the insertion of the lashes, and may involve the whole thickness of the lid and in some cases its whole breadth, so that the tarsal plate being completely torn away there is nothing left but a jagged edge showing the cornea. In other cases the torn flap remains hanging by one of its extremities.

These wounds are not very serious in themselves and repair easily, very often without any intervention. They only spoil the appearance of the animal, and in some cases cause chronic

irritation from the eye not being sufficiently protected from external injuries.

Treatment will be directed towards saving the eyelids. *No living tissues should be cut away.* The surgery of the eyelids, like that of any other organ, should be conservative and not mutilative. Gen. Smith rightly says that no matter how long a lacerated wound of the upper eyelid has remained unsutured excellent results may be obtained by paring the edges and using pin sutures. The tension of the figure-8 suture should be carefully regulated or the pins would come away too soon. On no account should loose skin be cut away, as however badly an eyelid may be lacerated it is quite capable of repair. He has never seen one that *failed to heal by first intention*, no matter how long neglected. Success depends on the horse being on the pillar-reins for a week; if the head be loose for a moment the animal rubs every stitch out, and the whole work must be repeated. If the flap is adherent it should always be sutured into position either by interrupted or twisted pin sutures. Hunting prefers blanket pins to steel pins as they are softer and less likely to cut too quickly through the tissues. Soft flexible metallic wire sutures are also very useful, especially in the horse. Gray, however, prefers for the dog two or three rows of interrupted silk sutures. One row is passed right through the thickness of the lids, another through the skin only, and a third, if possible, through mucous or conjunctival membrane only. The superficial sutures should be made with fine needles and fine silk.

Cicatrization should be allowed to take place under a scab. If the sutures cut away before firm cohesion is obtained, they should be replaced by others. Dusting the wound after it is sutured with an impalpable powder of iodoform assists in the formation of a scab without underlying suppuration. Iodoform also acts as a wound sedative and prevents itching, which causes the animal to rub the part. This scab should not be removed by repeated washings with antiseptic lotions.

These remarks apply to the cat and dog as well as to the horse.

Other lacerations, caused by a hook, especially the hook of the pillar-rein or collar-shank, or a nail, also affect the free edges, but are more or less vertical in direction.

Here again all possible means should be taken to produce as far as possible a regular cicatrization, with the object of preventing any deformity of the eyelid by its being turned in one direction or another. Remarkable restorations can also be effected in these cases, the wounds often healing by first intention.

Traumatisms of all kinds which may affect the eyelids, particularly the upper, have the special feature that they produce an œdema which is generally so marked as to attract attention and make the condition appear more serious than it really is. The infiltration of the tissues distends the skin, which becomes smooth and shining. The upper lid takes the form of a cap covering the greater part of the globe. The palpebral opening is reduced to a cleft through which the conjunctiva protrudes in the form of a reddish swollen ring, and from which there is a discharge of tears mixed with mucus, pus, or blood. On this swollen or projecting conjunctiva there very soon forms a false membrane which has nothing specific about it, being simply due to the necrosis of the epithelial layer.

The examination of this condition should only be undertaken after having put the animal well under restraint, as it is very painful. If the eyelid is previously rendered insensitive by cocaine the examination and treatment can much more conveniently be carried out. Then sometimes a jagged wound caused by a rough body can be found, sometimes a punctured or clean cut wound, both conditions needing to be carefully probed; sometimes there are one or more abrasions, not penetrating the thickness of the skin, resulting from rubbing, scratches and falls, such as are produced by the violent unrestrained movements of an animal suffering from colic; lastly, there

may be no trace of any cutaneous lesion. The condition will then be due to a simple contusion or to a long continued compression of the part caused by the poll-strap or other part of the headstall becoming fixed in that position from attempts on the part of the animal at slipping the headstall, as Nicolas has actually seen on several occasions, and said by General Smith to be common in troop horses. In this last case the attendant will possibly describe having found the horse with the headstall half off and only kept on by the throat lash, and the poll-strap being caught over the orbital arches, where it stopped the circulation.

Treatment. Even penetrating wounds which are limited to the eyelids are healed fairly quickly by simple antiseptic applications. If neglected for some time after their infliction, especially when contaminated with earth, they may, in certain districts, be followed by all the signs of the common wound infections—tetanus, septicæmia, or malignant œdema.

Cleansing injections, and the application of such agents as tincture of iodine, iodoform in æther, compound tincture of benzoin, touching with copper sulphate or silver nitrate, soon lead to the wound healing rapidly. If a fistulous wound forms, the possibility of a splinter of bone from the orbital arch being at the bottom must be considered. Warm or cold lotions, or even expectant treatment suffices in cases of simple œdema. A few scarifications of the swollen conjunctiva parallel to the free margins of the eyelids, in cases of extreme tumefaction, often lead to a favourable termination. A few drops of a solution of atropine with adrenaline and cocaine may be instilled to prevent congestion of the iris or complications affecting the pupil.

Lastly, if there is a fear of any marked deformity, such as an ectropion following on the cicatrization after the loss of a large portion of the lid, this may be prevented by an autoplastic operation, as performed by Bayer and Morkeberg; but this operation should not be attempted unless the wound is healthy and there is every chance of its healing successfully. [In the case of superficial wounds fuller's

earth, or equal parts of this and boracic acid give good results. In neglected wounds where the flap of the torn eyelid has been allowed to cicatrize irregularly, leaving a permanent breach of continuity, autoplasty may be performed with every guarantee of success, even after several years have elapsed since the injury.

Colobomata or congenital fissures or gaps in the eyelids, especially the lower, so often seen in sporting dogs and in foals, should be remedied if possible by an autoplastic operation].

Affections of the Palpebral Muscles.

The Orbicularis. *Spasm of the orbicularis.* This may be tonic or clonic. In the *tonic* form the closure of the eyelids is more or less marked, and exists permanently or intermittently. This is usually a reflex symptom of some local affection, such as keratitis, conjunctivitis, irido-cyclitis, or foreign bodies. Not only does it inconvenience vision already considerably obscured from other causes, but it sometimes prevents an examination of the affected eye. Further, it may be a cause of œdema of the conjunctiva and cornea.

In certain cases of irido-cyclitis in the horse Nicolas has seen an affection of the cornea which was slightly salient, confined to a region of the constricted palpebral fissure, the only cause of the condition being the compression caused by the blepharospasm. It may also cause entropium.

Clonic blepharospasm is much more rarely observed. However, Mouquet has reported two cases, one in a horse, the other in a dog, and Parant has seen one case in a cow. It is manifested by repeated winking of the lid.

In the dog the blinking or twitching was accompanied by movements of the face and ataxic symptoms consequent on the distemper; the animal had also suffered from corneal ulcers, iritis and panophthalmitis. This case is without doubt one of chorea consequent on distemper. Temporary or intermittent twitching is also seen during an attack of convulsions in this malady. In the horse 180 movements of the lids of both eyes were counted in a minute immediately

after work, then the animal became quite normal after a period of rest in the stable. At the same time a rapid backward and forward movement of the membrana nictitans could be seen, denoting some stimulation of the sixth cranial nerve which supplies the posterior rectus muscle, and fibrillary twitchings of the muscles of the face supplied by the seventh or facial nerve.

In Parant's case, the clonic palpebral contractions were associated with other contractions of the muscles of the head and neck and with laminitis; all these symptoms occurred in a cow suffering from a vaginal discharge after parturition. They were probably due to auto-intoxication.

Several similar cases have been observed in man, and clonic unilateral spasm of the eyelid, is often the result of local irritation in the eye similar to those mentioned as causing tonic spasm, whilst double spasm is the effect of some nervous condition, such as neurasthenia. *Points of compression* exist, usually on the circumference of the orbit at the points of emergence of the periorbital nerves; the compression of these nerves has the effect of stopping the blinking.

Regarding *treatment*, a local cause must first be sought for. Sometimes it may be necessary to cocainize the eye before a proper examination can be made. It is always advisable to do this unless the various parts of the front of the eye can be seen.

Paralysis of the Orbicularis is consecutive to alterations of the facial nerve, and is shown by the eye being widely opened, by the absence of winking of the lids and by the lower lid being relaxed and drooping away from the eye. The closure of the eyelids being insufficient to cover the eye, the condition known as lagophthalmos is produced. As symptoms of an affection of the facial nerve, the two sides of the face are not symmetrical: the lips may be drawn to the healthy side, and the nostril on the affected side may be collapsed, constricted, and immobile during inspiration.

In man, paralysis of the orbicularis muscle as a rule points

to some peripheral lesion of the facial nerve. When the lesion is nuclear it is usually accompanied by paralysis of several cranial nerves. This is also seen associated with atrophy of the masseter and other facial muscles in the dog.

In a case of facial hemiplegia in the horse with paralysis of the orbicularis and of the muscles of the ear, Vosshage found on post-mortem examination a thrombosis of the left posterior cerebellar artery, near the point where it comes off from the basilar, the thrombus interfering with the nutrition of the nucleus of the facial nerve. The nerve could still be stimulated.

Treatment should be directed towards the prevention of lagophthalmos if possible (*See later*).

The Levator of the Upper Eyelid. *Ptosis* or *blepharoptosis*. By this is meant a falling of the upper eyelid so that it covers the eye more than normally. It may be symptomatic of other local affections, such as enophthalmos, atrophy of the eyeball, microphthalmos, etc.

It is said to be *sympathetic* when it is the result of paralytic lesions of the cervical sympathetic. Experiments on animals by Pourfour, du Petit and Claude Bernard, have demonstrated the possibility of its occurrence, and observations by Ogle and Panas in man, its clinical entity. Accidental or operative traumatisms, glandular or other tumours attacking or compressing the nerve in its cervical or even its intrathoracic course may cause ptosis. Sympathetic ptosis is least well marked and is accompanied by miosis with a normal reaction of the pupils, and slight exophthalmos and hypotension. Lastly ptosis is *paralytic* when it arises from a paralysis of the levator of the upper eyelid, due to a lesion of the muscle or of the third nerve. It is, in the horse, often the result of fracture of the orbital rim or process of the the frontal bone. It is seen in some cases of psammomatous growths in the lateral ventricles, and in certain tumours pressing on the cerebrum or cerebellum. Such tumours are often secondary to those arising from the dental alveoli, and reaching the brain by a process of extension *viâ* the maxillary

and frontal sinuses, the bony plates encasing them, as well as the cranial cavity, not rarely becoming softened and absorbed in the process. In man it is frequently congenital in origin and hereditary. Prinz has seen it occur in the horse after the extirpation of a melanoma of the orbit, the operation having damaged the levator muscle. Vosshage, in a horse, and Dutrey, in a cow, have noted a slight degree of ptosis accompanying the symptoms of facial paralysis. It is seen in facial paralysis in consequence of new-growths at the root of the seventh nerve. Vachetta states that Sir Charles Bell caused ptosis in the ass after dividing the facial nerve. In the cow Moussu and Hamoir have seen ptosis caused by tuberculous lesions of the meninges and of the brain situated in the inferior and lateral parts of the isthmus. In the dog it may arise in chronic cerebral meningitis as a complication, or as a sequel to distemper or tuberculosis. It may also occur from a new growth occurring on the upper eyelid and its consequent weight over-tiring the levator.

Anomalies in the Direction and Position of the Eyelids.

Trichiasis. When the eyelashes in normally placed eyelids have an abnormal direction, either congenital or acquired, so that they irritate the cornea or conjunctiva, the condition is known as *trichiasis.* This anomaly, seldom reported in veterinary literature, is not always shown by photophobia, lacrimation, the formation of opacities, ulceration of the cornea, etc. It is commonly seen in the smaller breeds of dogs, such as the Pekingese and Japanese spaniels and toy Pomeranians, in which it seems to have an hereditary tendency. It is also occasionally encountered in the cat, and in the canary and other birds, in which small feathers generally take the place of the hairy eyelashes in mammals.

Distichiasis is a term applied when two rows of eyelashes are present, one of which arising from the glands on the free edge of the eyelids rubs on the eyeball, and the other being normally situated and taking a proper direction.

It is frequently seen in the Pekingese and other miniature

spaniels, sometimes in the British and French bull-dogs, and occasionally in other breeds. It is rare in the other domesticated animals. As in man so in the dog there is an hereditary predisposition to it; and in its incidence it follows the law of Mendel.

The abnormal eyelashes spring from the puncta or outlets of the Meibomian glands. They are usually few in number, and may be seen on the free margins of both eyelids. In appearance they are short, stumpy, rigid, fragile, isolated and blunt. Beyond perhaps causing a watery eye, they do not generally give rise to serious disturbance to the cornea. Occasionally, however, they set up an abrasion or even a deep ulceration of the cornea, with photophobia, blepharospasm, lacrimation and consequent opacity.

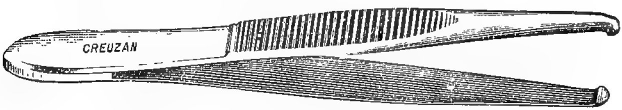


Fig. 149. Epilation or Ciliary Forceps.

This anomaly must be looked for to be seen; it should always be suspected in cases showing lacrimation, photophobia, ulceration of the cornea and blepharospasm, especially in those breeds most liable to it. For its detection an oblique as well as a frontal examination of the margin of both eyelids must be made in a good light, when the glistening, more or less transparent or translucent, short, sometimes blunt, stumpy hairs can be detected].

Pulling out the lashes which take a wrong direction is the usual method of intervention. This is done in the human subject by means of special small forceps with broad incurved beaks. These or any close-gripping dressing or artery forceps can be used in veterinary practice, if necessary. This method is, however, only applicable to distichiasis. Dog-fanciers cut off the offending eyelashes close to the

eyelids, as they often do the incurved portion of the eyelid in entropion, by means of scissors. Practitioners, as a rule, prefer to remedy trichiasis by means similar to those adopted for the removal of entropium.

Entropion or Entropium. Entropion or turning in of the eyelids on their mucous faces is one of the most common affections of the eye in animals. Every veterinary surgeon must have had occasion to operate for this condition a good many times, but in spite of this experience it cannot be said that a cure can be obtained at will in every case unless the method suitable to the case is applied.

It is especially common in the dog, particularly in certain breeds with a large amount of loose skin about the face; some breeds of sporting dogs, especially the sporting spaniels, setters and retrievers, the Great Dane, the St. Bernard (Serres), bull-dogs, chows and Pomeranians are more subject to it than the smaller breeds of spaniels, which are very much more liable to trichiasis. The narrowness of the tarsus, which is not cartilaginous in the dog, predisposes to the condition. It has also been seen in the cat, horse and even in lion cubs (Bassi). In dogs there is often an hereditary predisposition to it, and it falls within the hereditary law of Mendel, as do trichiasis and distichiasis. It also occurs after the eyeball has been enucleated.

Etiology. Entropion is *congenital* or *acquired.* When congenital, it is frequent in breeds with a large amount of loose skin on the face. Aubry, Hamon, in foals, and Bourdeau, in a mule, have seen *congenital* cases. When *acquired* it may arise from a variety of causes, of which those commonly incriminated by most authors are cicatrices of the conjunctiva occurring parallel to the edges of the tarsal margin, and in the dog follicular mange and chronic eczema on the eyelids and around the eyes. Fröhner makes special mention of a follicular conjunctivitis in this animal, but Mégnin thinks, and Gray agrees with him, that it is due to spasm of the eyelid—blepharospasm—which tends to turn the free borders of the lids inwards.

This contraction of the orbicularis is often an easily observed and genuine reflex phenomenon, but it may be essential, and the diagnosis is quite problematic. If *reflex*, the contraction is consequent on certain ocular affections, more particularly on ulcerations of the cornea. If *essential*, it has its origin in an acquired habit of closing the eyelids more than is normal, which causes what may be called an increase of tonus. This may happen when the lids are not sufficiently stretched by an atrophied eye or one which from some cause or other has retreated abnormally into the orbit, and in fact many authors state that entropion is easily produced in thin dogs with sunken eyes. This may also be the case when the animals are kept shut up for a long time and sleep more than normally, and Mégnin states that it is commonly,met with in a slight degree in such animals. It is rarely, if ever, seen in those breeds having prominent or advanced eyeballs. At the commencement of an entropion, whatever may be the primary cause, the eyelashes touch the cornea and the irritation produced is sufficient to give rise to a reflex spasm which (the effect becoming the cause) does not allow of the condition recovering spontaneously.

Symptoms and Diagnosis. The affected animal shows signs of lacrimation and photophobia, caused by the irritation of the cornea. One of the eyelids (sometimes two), is turned inward, in such a manner that the eyelashes, or even the hairy skin come in contact with the eyeball. In the dog a common position for the entropion is the temporal half of the lower lid. In pet dogs, such as the miniature Pomeranian, the Japanese and Pekingese spaniels, it chiefly affects the upper eyelid; in sporting dogs, such as the retriever, principally the lower eyelid; and in the bull-dog, chow and cat, usually both eyelids. But in any breed either the upper, lower or both eyelids may be involved. Very often in the larger breeds, such as great Danes, retrievers and setters both eyelids are curved inward more from the external canthus than the internal canthus. According to the degree of the turning in of the lid and the time the condition has lasted,

the cornea is more or less affected; there is desquamation of the epithelium, infiltration, pannus, or even small ulcertions. These conditions, however, are very frequently absent.

Entropion must be differentiated from trichiasis and distichiasis, which should not be difficult.

Prognosis. The affection is a tenacious one, and is liable to recur if suitable means are not adopted to remedy a given case. Its gravity consists in the defective sight caused by the chronic opacity of the cornea to which it may give rise. Further, from the lacrimation and the discharge (which is frequently accompanied by muco-pus) which it causes, gives the animal an unsightly appearance.

Treatment. This is purely surgical, but the number of different methods of procedure only shows the difficulty of always arriving at a satisfactory result. In any case the object is the same, viz., to bring back the free margin of the eyelid to its normal position. An operation should be attempted as soon as the diagnosis is sure, for the condition has rarely any tendency towards a spontaneous cure, for reasons above explained.

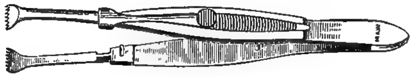
Cauterization, *excision*, or *suture* may be used.

Cauterization. The actual cautery, which has been used by several practitioners is described by Magnin, and has recently been introduced into human ophthalmic practice. It needs a little practice, and some precautions which the other methods do not demand, but on the other hand it leads most constantly to good results.

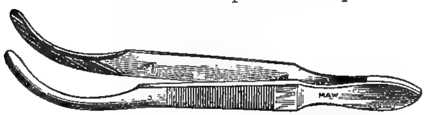
Anæsthetize the subject by the Dastre-Morat method (the subcutaneous injection of morphia 15 centigms., followed twenty minutes after by inhalations of chloroform). Gray, however, considers local anæsthesia by cocaine or novocain injection into the thickness of the skin is quite sufficient.

Muscular relaxation being complete, mark by means of a pen or special pencil the line of inflexion of the eyelid, and then fix this in place by Desmarres' forceps. Then with the point of a Paquelin's thermo-cautery, previously heated to a dull red heat and cooled to a grey heat, trace a line between

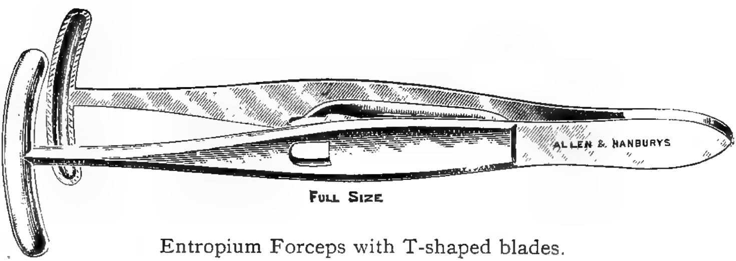
the line of inturning of the eyelid and the ciliary border, but considerably nearer the former. This line should extend beyond the limits of the entropion. "The cauterization should be effected by always directing the instrument from the least turned-in part to that most affected, that is to say, in the lower lid for example, it being the most commonly affected, by going from the external angle of the eye to the internal." The



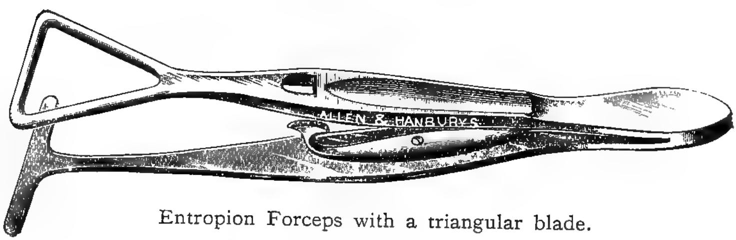
Bryant's Hæmorrhoidal Forceps suitable as Entropium Forceps.



Von Graefe's Entropium Forceps.



Entropium Forceps with T-shaped blades.



Entropion Forceps with a triangular blade.

same line should be gone over five to eight times, and "the operation is complete when the tarsus is straightened under the action of the heat. A single line is sufficient, but when the part turned in is relatively considerable and extends for

more than a centimetre, the line of cauterization must be broader, which can be arranged by holding the point of the cautery on its broader surface.

Desmarres' forceps greatly facilitate the operation, and have the advantage of protecting the eye from slips and radiation; it is not, however, indispensible, as the eyelid can be kept tense by the fingers.

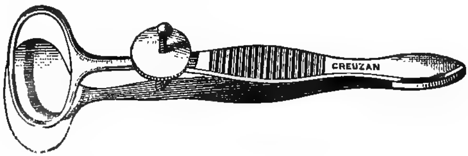


Fig. 150. Desmarres' Forceps.

After the operation the fore limbs should be tied together to prevent the animal rubbing the part in consequence of the irritation which the formation of a scar is sure to produce. If suppuration occurs, bathe the cauterized parts with warm boiled water or lead lotion. The immediate results of the operation last for about 18 to 24 hours. But whatever good results it may give, the majority of practitioners prefer the method of excision.

Excision. This method may be carried out under the influence of a local anæsthetic, such as cocaine, novocain, stovaine, or alypin with adrenaline or some of its substitutes. It is what may be called the classical method, which has been generally adopted in the dog and cat as well as in the horse. With the fingers, or by means of dressing, special, or artery forceps, a fold of skin parallel to the free margin of the eyelid and quite close to it (about half-a-centimetre away) is raised up, making its length, breadth and depth proportionate to the extent of the entropion.

Then by means of scissors, or preferably with a bistoury, excise this shred of skin from its base. Afterwards bring the edges of the wound together with a few interrupted sutures.

For small and young pet dogs a deep incision of the skin

and other membranes at the outer canthus, with suturing up a fold of skin above the affected eyelid may be all that is required. This is illustrated in Fig. A, p. 475. If, however, this fail to give the desired results excision of an elliptical or crescentic portion of skin and of the orbicularis muscle

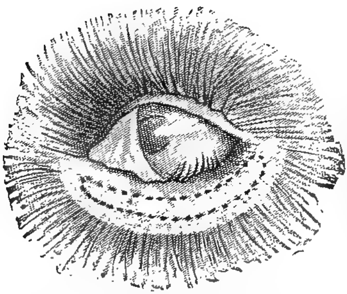


Fig. 151. Operation for entropion (dog). The portion of the skin excised is limited by the two curved incisions (Cadiot and Almy).

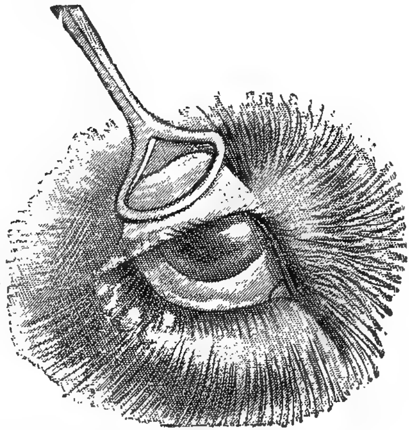


Fig. 152. The fold of skin to be excised is held by the forceps. (Cadiot and Almy).

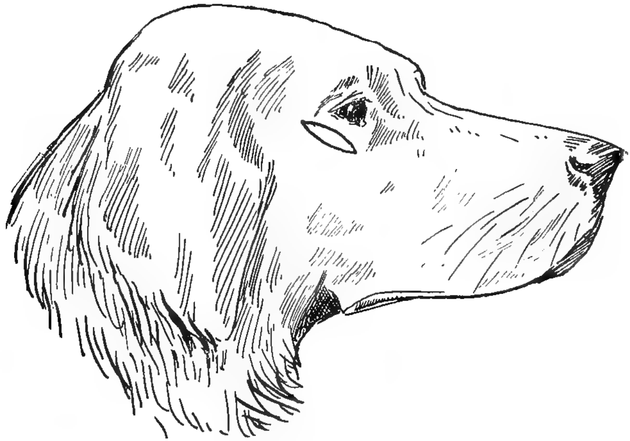
parallel to the margin of the eyelid, and suturing up the consequent wound should be adopted. These two methods are also advised for trichiasis.

In large and adult animals, excision of a good-sized oval, elliptical or crescentric fold of skin and orbicularis muscle, either horizontally above the upper or lower or both lids, or obliquely or perpendicularly to the outer canthus, as the case may require, is advisable. (Figs. B, C, pp. 475, 476).

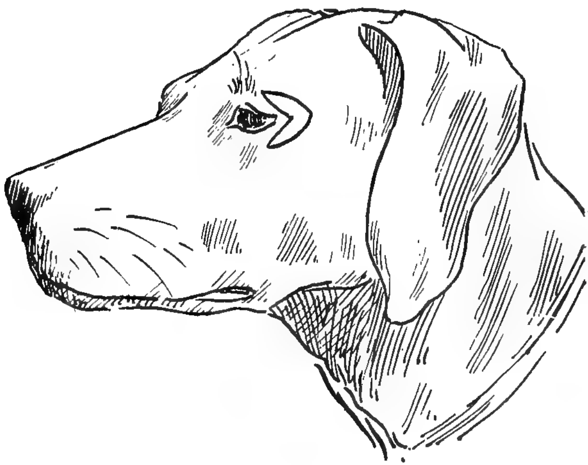
In the case of incurvation of both eyelids at the temporal angle, leaving a too narrow palpebral fissure (although the free margins seem lengthy enough when straightened out) and accompanied by intense spasm of the orbicularis muscle, a deep and somewhat lengthy incision should be made through all the tissues at the outer canthus, in addition to excision of

Simple incision of outer canthus with suturing up a fold of skin above upper Eyelid in slight cases of Trichiasis or Entropium. (Fig. A).

Simple incision without suturing of the outer canthus, and excision of an almond-shaped portion of skin a short distance away from outer canthus, in certain cases of double external Entropium. (Fig. B).



Excision of melon-seed-shaped portion of skin obliquely below the lower eyelid, and extending somewhat posteriorly to the external canthus, in Entropium of lower eyelid. Berlin-Mégnin method. (Fig. C).



Excision of an arrow-shaped portion of skin in double external Entropium. Schleich's method. (Fig. D).

an elliptical or oval fold of skin horizontally above either or both eyelids or obliquely or perpendicularly to the outer canthus, if it may be necessary to prevent a recurrence of this anomalous condition. Schleich has suggested a modification of these methods. It consists in excision of an arrow-shaped portion of skin a short distance away from the outer canthus (Fig. D, p. 476).

Fröhner's method consists in removing a fold of skin raised by the fingers or forceps, sufficiently to efface the entropium. This leaves a somewhat circular wound, which is closed with a button suture. Many authors merely remove the fold of skin and underlying muscle without suturing the resulting wound, which is allowed to cicatrize without any after-treatment. The objection to this procedure is that a hairless, shiny cicatrix remains as a permanent blemish.

Care should be taken not to excise more skin than seems necessary, lest a disfigurement of the eyelid or lids (ectropium) remains after cicatrization has taken place; also that the conjunctival membrane underlying the skin and muscle is not cut through in the incision; and finally, that the whole depth of the skin, as well as some of the fibres of the orbicularis, is divided in the incision and removed. If the operation is a failure from not enough skin being excised, another operation should be performed. Berlin, in his operation, penetrates the conjunctival membrane and does not see any objection to it. In the horse the various methods used for the dog are applicable. The resulting operation-wound may, in many instances, be covered with simple collodion fortified with a thin layer of teased out cotton-wool.

Marlot inserts a few pins at the base of the fold which he cuts off and then places a twisted suture round them, which requires less instruments and can be more quickly performed.

Suture. Bourdeau having to operate on a young mule the owner of which refused to allow the removal of skin with a knife, inserted a shoemaker's suture round the base of a fold of skin parallel to the free edge of the eyelids. After a few days the fold necrosed and the eyelids had assumed a normal position.

A similar operation is sometimes performed in slight cases of entropium in the dog. It consists in taking up a fold of skin, passing two pins through it, and twisting silk or thread round them in the form of a figure-8 or twisted suture. No skin is removed, but the sutures in sloughing-out leave wounds, which in cicatrizing bring about contraction, and hence the raising of the eyelid. It is not a very effectual method and is only recommended in slight cases of entropium and trichiasis in small dogs.

In entropium resulting from enucleation of the eyeball, an artificial eye remedies the defect.*

Ectropion or Ectropium. This is the opposite condition to entropion, as the palpebral edge is turned outward so that the surface of the conjunctiva is visible. It may even be said that there is ectropion every time the palpebral edge is not exactly applied to the eyeball and consequently a more or less deep gutter is formed.

This anomaly, less frequently observed than the preceding, is not, however, rare, and is most common in the lower lid, both in the horse and dog. In this latter animal it may be congenital, and in certain breeds, such as the blood-hound, fox-hound, St. Bernard, setter, retriever, and spaniel, it is considered to be a point of beauty. There is an hereditary predisposition to it, and its incidence follows the law of Mendel.

Etiology. Ectropion may arise from different causes.

Cicatricial Ectropion is the best characterised in animals. It is produced by the retraction of cicatricial tissue which occurs in wounds of the eyelids in which there is loss of skin. Any traumatic injury may give rise to the condition, even those which are surgical; it thus happens that cauterization and the other methods employed in the treatment of entropion, which exceed the desired end may give rise to ectropion. Any alteration in the skin tending to cause retraction, such as eczema, mange, erythema caused by prolonged discharge of

* [Walley, *Veterinary Journal*, Vol. ix., 1879].

tears, may lead to the same result. This form is seen in the horse from loss of tissue of the upper eyelid from an injury due to prolonged decubitus and the resulting wound contracting.

Paralytic Ectropion is met with in the lower lid in lesions of the facial nerve, and results from paralysis of the orbicularis. It is also seen in man and in the dog in old age when the tissues are atonic *(senile ectropion)*, then the lower lid falls in consequence of its own weight and forms a gutter, instead of being applied to the eyeball. Nicolas has seen the same condition in horses having pendulous lips.

Mechanical Entropion is consequent on the presence of tumours of the orbit or of the eyeball which push the lids before them, or in the inside or outside of the lower lid, when the weight of the growth pulls the lid down. In the bull-dog it often originates from thickening of the conjunctiva, due to a granular condition of the inner surface of the lower lid and anterior face of the membrana nictitans. According to General Smith, whose remarks on the eye are always worthy of respect, ectropion of the lower lid in the horse is relatively common in tropical countries where flies are a pest. The flies settling on the margin of the lid and around the orbit, the animal rubs the part on the inside of the knee, and thus sets up irritation which produces a thickening and an inflammatory œdema of the conjunctiva, which often leaves a permanent thickening and an eversion of the lower lid. The caruncula lacrimalia also becomes swollen.

Whatever may be its origin, ectropion is accompanied by reddening and thickening of the conjunctiva, chronic discharge of tears, and the irritation of the skin produced by this last symptom may even form a new cause for its development and persistence.

Treatment. In all operations on the eyelids strict antisepsis should be observed but no strong antiseptic solution should be used, else irritation of the eye would be set up. The parts to be operated upon should be rendered bloodless and

insensible by the use of novocain or cocaine with adrenaline. The cause must first of all be discovered. The discharge of tears should be stopped if it be the cause. In old horses in which there may be seen the commencement of an ectropion of the lower lid with eversion of the punctum lacrimale, if the conjunctival culs-de-sac be searched they may be found to contain an encrusted foreign body, hayseeds, bits of straw, dust, filaria, or even small tumours (Nicolas) causing the lacrimation. The usual ducts must also be examined to see if they are obstructed from any cause.

Treatment. To remedy paralytic ectropion actual cauterization of the palpebral conjunctiva may be tried as in man, in preference to chemical cauterization, which has been advised by Di Girolano in the horse, on account of the difficulty of limiting the action of the caustic which always dissolves more or less on a damp surface.

Paquelin's thermo-cautery, which is easy to handle, used with Desmarres' forceps are indicated, as for entropion. The animal being anæsthetized, if necessary, and Desmarres' forceps applied to protect the eyeball, one or several firing lines may be traced parallel to the edge of the lid. Gray has found that local anæsthesia is generally satisfactory to remove the cause for the animal to act on the defensive, and that the electric cautery is preferable to the thermo-cautery. General Smith has found that in ectropium, seen so often in the lower lid of the horse in tropical countries, snipping away the thickened conjunctival membrane with a pair of scissors and leaving the resulting wound to contract by granulation, gives very satisfactory results. As an absolute preventive eye-fringes should be worn.

In ectropium in the lower lid in the dog, due to a lax conjunctival membrane and lid, removal of a V-shaped portion of the whole thickness of the lid, including the sublying conjunctival membrane, but leaving the free margin of the lid intact, and bringing the edges of the wound together with pin or ordinary sutures answers very well. Some operators make a horizontal incision the whole length of the lid before

excising the V-shaped portion and its sublying conjunctival membrane, but do not suture the horizontal wound. Other operators, in slight cases, prefer Snellen's method, which consists in drawing the everted mucous membrane back into the sulcus between the lid and the globe by a suture passed

Figure showing Excision of a V-shaped portion of skin in the treatment of Ectropion of lower eyelid of the dog.

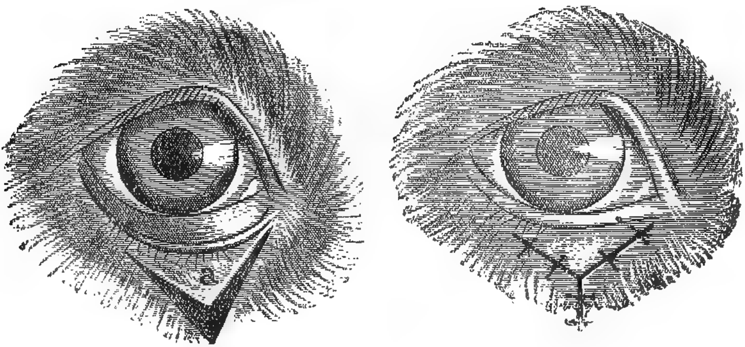
deeply through the conjunctiva at two points $\frac{1}{4}$–$\frac{1}{2}$ inch apart, according to the size of the dog, and brought out below, and tied over a piece of tubing or a dossil of lint or gauze. The suture is tightened day by day until it has nearly cut through. Rubber threads may be used instead of silk.

The *Operation for Cicatricial Ectropion* comprises numerous procedures in human ophthalmology, of which the most simple will be described—that of Sanson—Wharton Jones (Fig. 153 and 154).

"The cicatricial tissue is circumscribed by V-shaped incisions, the triangular flap is then detached and made movable

from its point to its base," which allows it to be lifted up, then the lips of the incision are sutured together so as to obtain a Y-shaped figure" (Cadiot and Almy).

In the dog, in which the skin of the eyelid is very movable, the operation may be simplified as follows: Make an incision parallel to the free edge of the lid, and going through the whole thickness of the skin, detach and make the edges of



Figs. 153 and 154. The VY operation for Ectropion. *a*, Triangular flap. Sanson—Wharton Jones' method. (Cadiot and Almy).

the wound movable throughout their whole extent, and sufficiently deeply to allow of sutures being inserted from right to left instead of from above downwards, so that the horizontal incision becomes vertical when sutured.

This operation, attempted by Duquet and Truc on a horse suffering from cicatricial ectropion of the upper eyelid, could not be carried out as regards the suturing, on account of the skin not being sufficiently movable.

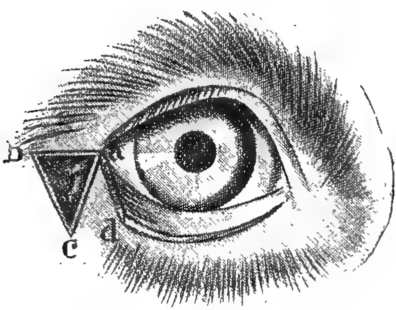
Blepharoplasty. Duquet and Truc then tried autoplasty. A vertical fold of skin, adherent by its lower pedicle, was dissected out in the temporal region and rendered mobile by torsion of its base in such a way that it could be placed horizontally between the lips of the incision. Careful suturing

and a light dressing of tarlatan (gauze) and collodion completed the operation, which resulted in the cure of the ectropion.

To prevent the formation of an ectropion which would have had almost fatal consequences, on account of the loss of substance of the lids from a wound, Mörkeberg in two cases saw successful results in the horse with autoplasty, the piece of skin with a pedicle being moved from the neighbouring region.

Cadiot and Almy describe the operation recommended by Dieffenbach and von Graefe for man, which may be performed on the dog suffering from ectropion due to inflammatory retraction of the skin.

It comprises incision of the external commissure following the line *ab*; partial excision of the everted lid *ad*; excision of a triangle of skin *bca*; displacement of the cutaneous flap *cad*, and the passing of a double suture bringing together the lips of the wound *ad* and *ab*, and *ac* and *bc*. A trianglar flap, near the external commissure may also be excised, the flap including the whole thickness of the eyelid and the base of which corresponds to the free border of the lid. The resulting wound is then sutured. (Cadiot and Almy).



Operation for Ectropion in dog.
Dieffenbach's method (Cadiot and Almy).

Adhesion of the Eyelids. The eyelids may form adhesions to one another by their ciliary edges (*ankyloblepharon*) or to the eyeball, the ciliary edges being free (*symblepharon*).

Ankyloblepharon is *complete* or *incomplete*. In the first case the palpebral opening has completely disappeared; in the second it is only more or less constricted (*blepharophimosis*).

It is most commonly congenital and in this form according to Leblanc it is fairly often seen in the pig, dog and cat. Walther, Magin, and Robinson have also seen it in the foal.

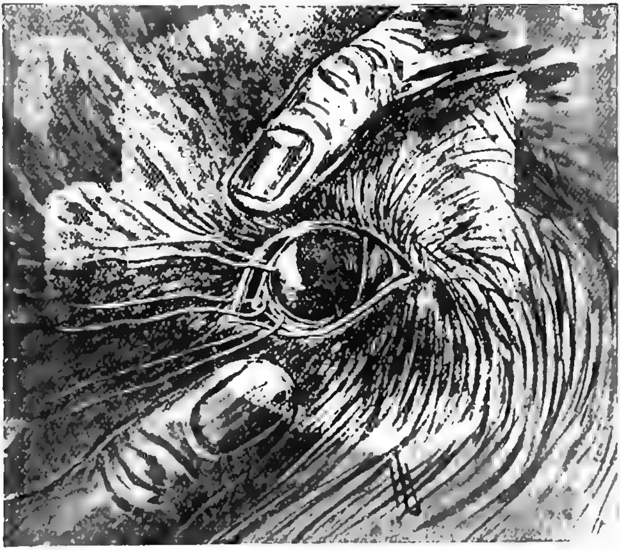
The carnivora usually being born with the eyes closed, and the epithelial layer which joins the eyelids not disappearing until the tenth to the fifteenth days, it is not possible to say that one of these animals has ankyloblepharon until some time after birth. In a case of double ankyloblepharon seen in a dog by Leblanc, of Lyons, he was able to distinguish very clearly the line of junction of the lids, as it was marked by a groove.

The operation which he performed was most simple: he raised the eyelids so as to form a fold, made a slight puncture on the line corresponding to the groove of the adhesion, introduced a director and cut along the furrow. The after-treatment simply consisted in frequent instillations of a warm solution of boracic acid; the cure was complete in a fortnight.

Blepharophimosis or a narrowing of the palpebral fissure, which gives the eye a small appearance, is commonly seen in small toy dogs, especially the Pomeranian and the Japanese Spaniel. It is often associated with trichiasis or entropium, and mostly of an hereditary origin. In the miniature Pomeranian it is a point insanely sought after by exhibitors. It is also seen in delicate dogs that are affected with a chronic generalized eczema and a chronic purulent conjunctivitis, and also in young dogs that are much confined to the house and in dark rooms, and is probably due to the persistent contraction of the retractor oculi not allowing the eyeball to press against the eyelids and thus cause their gradual widening during growth. In such dogs the eyeballs are up to the normal size, although the animal has a "pig-eyed" appearance.

It may be remedied by dividing the entire thickness of the external commissure and then suturing the divided mucous membrane to the divided skin (*canthoplasty*). Very frequently, instead of suturing thus the wound is left open, and the skin above the upper lid and below the lower lid is

sutured back to prevent the incision closing too soon and thus bringing the palpebral fissure to its former dimensions. This method is often adopted when the narrow palpebral fissure is associated with trichiasis or entropium in small breeds. It removes the trouble, widens the opening and gives the eye a bolder and brighter appearance. There is no need to fear a blemish.



Canthoplasty. Suturing mucous membrane to the skin.

Acquired Ankyloblepharon is very rare. It may be seen in a partial form resulting from ulceration and destruction of tissue on the margin of the lids, consequent on distemper. To avoid this the lids should be frequently lubricated with neutral vaseline. The only mention which can be found is a case of surgical ankyloblepharon by Bayer, in which he sutured the edges of the lids of a horse after scarifying them, in order to improve the appearance of the animal after enucleation of

the eye. This operation is called *tarsorraphy*, which has already been alluded to.

Symblepharon or adhesion of the eyelids to the eyeball has been seen by Vachetta in the dog and by Leblanc, of Lyons, in a cat. In Vachetta's case it was congenital and partial, and co-existed with other equally congenital anomalies, such as convergent strabismus, enophthalmos with an abnormal prominence of third eyelid, and atrophy of the cornea.

In Leblanc's case the adhesion was partial and existed on both sides to the same degree, and in each case towards the temporal angle; there was also entropium of both lids; these facts seem to suggest that the symblepharon was a congenital condition in this case, although the author considers that it was acquired. Acquired symblepharon is occasionally seen in the dog from the palpebral and ocular conjunctival membranes becoming destroyed from ulceration arising during the course of distemper. Treatment as for ankyloblepharon.

Leblanc operated by freeing the edge of the lid with a von Graefe's knife, the eyeball being fixed with forceps, he operated on the entropium in the usual manner by the excision of a fold of skin. After-treatment consisted in instillations of a solution of boracic acid and gently rubbing a small piece of yellow oxide of mercury ointment between the lids. The cure was complete in three weeks.

Epicanthus. This is a rare congenital malformation consisting of a fold of skin stretching across from the dorsum of the nose and projecting over the inner angle of the eye, hiding the inner canthus. It is seen on one or both sides of the bridge of the nose, and in some races of man, such as the Mongolian and Caucasian it is frequently seen in a more or less degree, and in the latter race it may disappear as manhood approaches. It does not appear to have been seen in animals.

It is removed by excising an elliptical piece of the skin or even excising the projecting fold of skin itself.

A Hairless Area of the skin around the inner angle in

the horse is sometimes observèd. It extends from about an inch to an inch-and-a-half of the free border of the lower lid and inner canthus and appears as a dark, shining, greasy smooth surface. It usually affects both sides of the face. Its cause or nature has not been determined. Beyond being somewhat unsightly it does not seem to be of any importance.

Lagophthalmos. When the occlusion of the eyelids is not complete the condition is called lagophthalmos (*lagos*, a hare).* The portion of the cornea or conjunctiva corresponding to the space between the lids, being constantly exposed to the air, may become irritated and the seat of serious alterations. The conjunctiva is thickened and assumes the appearance of skin, and the cornea becomes opaque and desiccated, undergoes necrosis, and may even be perforated. The tears, no longer driven towards the internal angle of the eye by the approximation of the lids, run down the face and irritate the skin.

The commonest causes are ectropion, pronounced exophthalmos, tumours of the eyeball, but the condition has also been seen in paralysis of the orbicularis (Nogés in the ox, Stockfleth, and Gotti in the horse). *Ablepharon* or *ablepharia* (congenital absence of the eyelids) and wounds of the lids with sufficient loss of substance, may also cause it.

In some cerebral affections, Graves' disease, and certain intoxications, the eyelids sometimes do not close.

Treatment should first of all be directed towards removing the cause, and if this is not possible the desiccation of the cornea must be prevented by the application of ointments or the instillation of oily collyria. In man there is a surgical method of intervention which consists in reducing the size of the palpebral opening by the union of the lids (after paring their edges), preferably at the internal angle of the eye (*internal tarsorraphy*).

* A fable states that the hare sleeps with its eyes open, which is the case with persons suffering from lagophthalmos, whence the name.

Tumours of the Eyelids. *Warts* are not uncommon, especially in young animals, in the ass, mule, horse, ox and parrot. They are rare in young dogs. The wart-like growths arising from the anterior face of the eyelids of birds, especially the parrot-tribe, are of a tuberculous nature and are diagnostic of tuberculosis. The same applies to the horny outgrowths. Warts which are frequent in old dogs, and cutaneous horns in the cat and dog, are often outgrowths springing from the wall of a Meibomian cyst, which is, in reality, only a sebaceous cyst. Smaller warts, generally pigmented, arise from the anterior surface of the free extremity of either eyelid, but chiefly the upper one. Small warts are snipped off with a pair of scissors, and their base deeply cauterized with nitrate of silver. The fibro-cellular warts in the horse and ox require to be enucleated. They are often eradicated by the internal or external use of arsenic, which must be prescribed with care.

Chalazion. Other small cystic, or apparently cystic, new growths are met with on the free edges of the lids, some standing out from the surface and situated in the skin; these are sebaceous cysts which have no inflammatory reaction on the surrounding parts, mentioned by U. Leblanc, but somewhat rare, for Nicolas has only seen one, on the lower lid of a horse. A puncture with the point of a scalpel causes the escape of some honey-like matter, which does not form again.

Projecting from the mucous surface but towards the exterior, these swellings are small inflammatory retentions of the Meibomian glands; they are infective, and are known as chalazia.

Boucheron has experimentally produced them in the rabbit by injecting bouillon cultures into the lid, as also have Deyl and H'la by inoculating a bacillus described by Deyl, (1893), as occurring in chalazion. "It is clear," says A. Terson, "that any organism injected into the tarsus will have a tendency to produce a small inflammatory nodule with

embryonic cells and a structure which will be analogous with that of chalazion."

Spontaneous chalazion is very rarely mentioned in veterinary literature. Schütt describes a case in a horse, which recurred and having the chalky contents which wounded the cornea; Larcher has seen it in birds. Meibomian cyst or chalazion is, however, comparatively frequent in the dog, especially when of a mature age, and forms a hard circumscribed swelling, gradually enlarging for months until it reaches the size of a pea or a small marble. It resembles a sebaceous cyst in nature and very often, like it, when left alone, gives rise on its outer surface to a wart-like excrescence which not rarely, unless totally eradicated, takes on malignant characters. It is situated on the free border and involves the entire thickness of the upper eyelid.

In Gray's experience the quickest and surest method of treatment is to excise a small triangular portion of the whole thickness of the eyelid, including the tumour, taking care the base of the triangle is at the free edge of the lid. The resulting small wound may either be sutured or left alone, when the remaining gap fills up in about a week without leaving any blemish. This method is found by Gray to give better results than curettage with a Volkmann's spoon, as, if any of the tumour be left behind, it grows again. In man, certain individuals are particularly subject to the condition.

Pilo-sebaceous cysts are occasionally found in the thick wrinkled upper eyelid, and the skin over the supraorbital region of certain breeds of dogs, such as the bull-dog and pug. These cysts contain hair commingled with sebum and the elements of pus, which are discharged through a fistulous opening in the skin. No *treatment* beyond excision or destruction of the cyst-wall will give any permanent benefit.

Sebaceous-looking tumours in the upper eyelid or its vicinity, are not infrequently observed in various species of birds maintained in confinement. Such tumours are circumscribed, prominent, and firm to the touch; they vary in size, according to that of the species, from a small pea up to a pigeon's or

fowl's egg; when cut into they are found to be composed mostly of a more or less sulphury-yellow, laminated, tough, cheesy material encysted in a capsule immediately under the skin. They are easily shelled out of their capsule. They closely resemble sebaceous cysts, which probably they are. Occasionally the encysted material is of a creamy consistence and has a primrose colour. If left alone the cysts sometimes burst through the skin and expel their contents. From their summit sometimes a horny process arises. Similar formations are at times found in the uropygium or oil-gland of the coccygeal region. Often only a single bird in a collection may be affected, but not rarely it may attack several at the same time and appear as an enzoötic. It is usually found in anæmic birds.

Larcher states that small lipomata the size of a small pea are met with in birds, rendering the opening of the eyelids very difficult; besides this, sub-mucous concretions of a non-organic albuminoid material, forming pyriform elevations under the skin, and small tuberculous swellings may also be seen.

The *treatment* consists in incising the tumour and evacuating the contents, and painting the interior of the capsule with strong tincture of iodine. Should the cutaneous wound bleed too freely, the free edges should be cauterized with a stick of nitrate of silver. On no account should the tumours be opened during their formation when the surrounding tissues are usually thickened and more or less inflamed.

Obstruction of the Glands of Moll or modified sweat glands, which empty themselves into the glands of the ciliary hair follicles, and are found on the free margin of the eyelids, is sometimes observed in dogs, especially in aged ones. It is manifested in the form of transparent cysts, varying in size from a poppy-seed up to that of a grain of millet, on the free margin of the eyelids.

Treatment consists in pressing out the contents of the cysts by means of a small pair of forceps. In the dog, there are in the upper eyelid two or three rows of the glands of Moll.

Granulomatous or *Inflammatory Growths* may be observed, now and again, in the free margin of the eyelids in young dogs. They vary from the size of a hemp seed to a large pea; they have a homogeneous consistence and a glistening, waxy appearance. They blend with the normal tissue but do not undergo central softening. They are unsightly, and should be removed by total excision. Similar formations are observed on other parts of the body. Their nature is unknown, but their histological characters resemble inflammatory tissue.

Fibromata, epitheliomata, sarcomata, actinomycomata, botryomycomata, tuberculomata, melanomata, adenomata, etc., occasionally originate in the eyelids, or they may extend to them from other parts.

Nicolas has seen, in a horse, a cyst the size of a pea the wall of which when microscopically examined was striated and elastic and had the appearance of an hydatid vesicle. Lustig, and Moulton have removed fibromata from the eyelids. Nicolas has, on two occasions, had to remove from the lower lid small pedunculated dermoids, about the size of a haricot bean, which were causing a chronic lacrimation and a flaccid condition of the lower lid with eversion of the lacrimal punctum. They were sufficiently hidden in the infero-external region of the cul-de-sac to have escaped the attention of other veterinary surgeons, who had been treating the animal unsuccessfully for conjunctivitis. Sarcomata have been met with in the horse and dog. If completely removed a cure may result (Reggiani), but there may be recurrence. M'Fadyean has seen recurrence three times in one case which eventually led to ectropion. Huss saw the maxillary sinus invaded in consequence of a recurrence. Margraf reports an observation in which he found a tumour the size of a pigeon's egg in the middle of the upper eyelid of a horse, due to botryomyces.

Tumours of the eyelids may develop to such an extent that they interfere with vision. Some varieties, such as the sarcomata, have also the inconvenience of becoming ulcerated and are then very repulsive in appearance.

Treatment consists in removing the growth as completely as possible and cauterizing the base of the growth in those which may recur. If the operation necessitates the loss of a great amount of substance it may be concluded by reuniting the lips of the wound by an autoplasty, to avoid deformity of the part after cicatrization. Marlot's method consists in fixing the base of the tumour with pins and removing it by means of a twisted suture applied round the pins.

Affections of the Membrana Nictitans and of the Caruncula Lacrimalis. The membrana nictitans, may become the seat of *wounds*. In the dog or cat they are usually due to scratches, and in the horse to pokes in the eye with a stick, or to it becoming caught in a spring hook of the rack chain. They are not of much importance unless the deeper structures of the eye become involved. Where there is a thin narrow strip of the free border hanging from the main body of the organ and floating about in front of the eyeball or in the conjunctival sac, as is frequently seen in the cat and dog, it should be snipped off with the scissors.

In the dog the free border of the membrana is occasionally turned over the front face of the organ and gives rise to a deformity. The overlapping portion should be cut off with pair of sharp scissors. Beside these and various other wounds similar to those which may attack the eyelids, the membrana nictitans may be the seat of a chronic inflammatory swelling [Fr. onglet] on its free border. In this position there is formed a prominent, reddish, more or less granular looking ridge which can always be seen in the internal angle of the eye and which causes a persistent lacrimation. According to U. Leblanc the affection may extend to "caries of the third eyelid," In two cases occurring in horses in Algeria seen by Cavalin, the alteration resulted from an obstinate case of chronic conjunctivitis developed during the hot weather. Nicolas has seen a double case in a dog, but he was not able to ascribe it to any definite cause. (*Vide* Displacement of the Harderian gland, p. 495). In the ox Leblanc found a spikelet of brome fixed in the internal face of the membrana nictitans.

Treatment consists in removing the tumefied edge of the membrana with a snip of the scissors, after drawing it slightly away from the eye to avoid injuring the surrounding parts. As a rule a cure can thus be effected.

It may happen (as in a case reported by Krait in a horse) that, tetanus being eliminated, the third eyelids cover the eyes to such an extent that they interfere with the animal seeing where it is going. Here the prominence of the membrana is clonic, and is increased during walking. Krait practised excision, after which the eye showed slight enophthalmos.

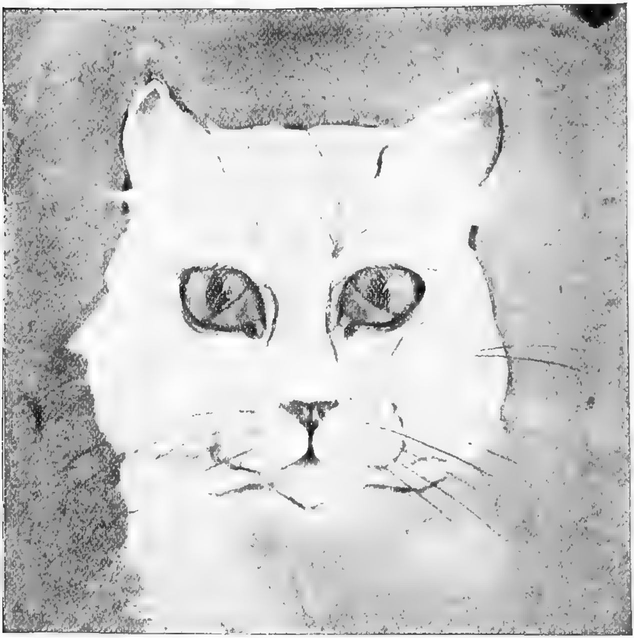
Persistent Projection of the Membrana Nictitans in Front of the Eyes. When the front of the eyeball is irritated or touched the membrana protrudes over the front of the eyeball, and as soon as the irritation is removed it passively (?) regains its normal position.

It is generally asserted that retraction of the eyeball is brought about by contraction of the choanoid or retractor muscle; this action presses the fatty cushion forward and thus the membrana is raised. Relaxation of the choanoid and contraction of the oblique muscle enables these two organs to regain their position at rest. But according to Heinrich Müller, Sir Wm. Turner and others, the non-striped muscular tissue (Müller's muscle) found in the orbital membrane and in the eyelid of man and many mammals also plays a part in the advancement and retrocession of the orbital contents.

When the cervical sympathetic is divided the non-striped muscular fibres of the orbital membrane and of the eyelids are relaxed, and in consequence the palpebral fissure becomes narrowed, the eyeball retracted, and the membrana nictitans protruded over the front of the eyeball. On the contrary, when the cervical sympathetic is stimulated by a galvanic current the eyeball becomes advanced, the palpebral fissure increased in width, and the membrana nictitans withdrawn.

In some pathological conditions the membrana nictitans persistently overlaps the front of the eyeball. It is symp-

tomatic of acute conjunctivitis, ulcerative and non-suppurative keratitis, wounds, injuries, foreign bodies—especially an oat-flight adhering to the cornea in the ox, and scales of metal in the dog—of the earlier stage of periodic ophthalmia, rabies, meningitis, and in the cat, of the debility of distemper or diphtheria.



Cat suffering from persistent protrusion of Membrana Nictitans.

The persistent protrusion of the membrana nictitans in the cat, as may occasionally be the case in the dog, may continue over the front of the eyeball and remain in this situation for some time, when the animal is suffering from anæmia, debility, or some unknown condition. It is very often not accompanied by any inflammatory or congestive disturbance

of the eye or its membrane. It is not a foreign body, and when not the seat of any structural alteration it will, in time, regain its normal position without any treatment whatever. Still, perhaps it would be advisable to administer iron, arsenic, nux vomica and quinine in pill form, and to apply locally to the eye a mild astringent lotion. Too irritating lotions or caustics often cause the conjunctival membrane covering the haw to become swollen, succulent and granular. It should not be excised, as taught by practitioners of the 18th century and some more modern authorities of the 20th century. The veterinary surgeon should not forget the aphorism of John Hunter, who likened the surgeon who only thought of the knife for the cure of surgical conditions to a bat with one wing.

Pigmentless Membrana Nictitans. The membrana nictitans in some dogs and in some other animals has no pigment in the free margin, and becomes unsightly in consequence of the pale pinkish colour being noticeable. It should not be confounded with the persistent protrusion of the organ.

A Granular Condition of the Posterior or Internal Surface of the Haw is nearly if not always found in the cat and dog, even in quite young animals. The part affected is generally situated on the surface of the conjunctiva covering the Harderian gland where the granules are collected into a group, the base of which is heightened in colour. It appears the granules are enlarged lymphoid spaces or follicles. Their constant presence would lead one to question whether they were pathological or physiological.

Displacement, Ectopia or Luxation of the Harderian Gland in the Dog. Gray considers that the *majority* of the cases of "onglet" described in French veterinary literature, and the one mentioned by Nicolas on p. 492, without any cause being attributed; (known in British veterinary literature as tumefaction of the membrana

nictitans or displacement of the orbital gland,* and in Dutch, German and Russian professional periodicals as adenoma of the Harderian gland), in the dog are nothing more nor less than dislocation or prolapse of the Harderian gland from its normal position at the inner angle and posterior or inner surface of the membrana nictitans. Vachetta, of Pisa, mentions a case † under the name of Procidentia Glandula Harderi, and criticizes the assertions of those authors who describe the condition as Adenoma.

This gland, in a great number of dogs having lax connective tissue, especially in the orbital cavity, is somewhat loosely attached to the body of the membrana nictitans, so much so that it can experimentally be turned out of its normal situation and become exposed above the free margin of the membrana. Although it may be encountered in any breed of dog, it is chiefly seen in the bull-dog, bull-terrier, sporting and toy spaniels. It may occur in one or both eyes, and can be easily replaced—to become sooner or later dislocated again. It may also return to its normal situation spontaneously. There is an hereditary tendency towards the condition, and several members of a strain or family may become affected.

It appears as a small, reddish, somewhat globular tumour, from the size of a pea to that of a small marble, overlapping the free margin at the internal angle of the membrana nictitans. It becomes from a bright red to, sooner or later, a dark purplish colour, according to the time it has been out of

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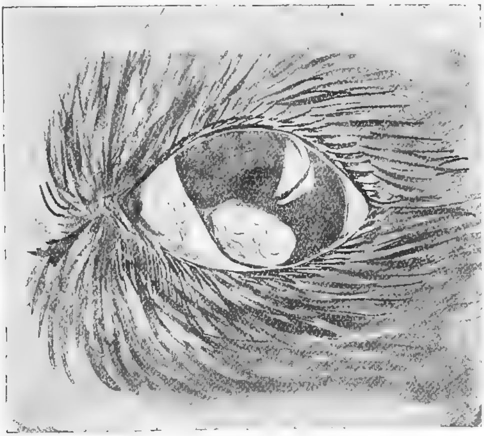
* The orbital (zygomatic) gland is the name given to the superior buccal glands. Externally it is covered by the orbital membrane, the internal pterygoid muscle and zygomatic process; internally by the external surface of the orbital membrane and pterygoid. It is a mucous gland and opens in the mouth in the region of the last molar. Each lobe of the gland has a large duct and two or three smaller ones, termed the ducts of Nuck. The larger duct has almost the calibre of Stenson's duct, and the smaller are sometimes absent.

† Trattato di Oftalmojatria Veterinaria, p. 172; and *Il moderno Zooiatro*, 1880, February No.

its normal position, and also to its being somewhat constricted by the upper edge of the membrana on the one hand and by the eyeball on the other; and further from its being exposed to dust and other irritating influences, which give it an inflamed and swollen appearance.



Luxation of the Harderian gland (Dog).

It is attached to the posterior surface of the membrana by a more or less sessile or peduncular base. Sometimes the free border of the membrana is turned down anteriorly, in consequence of the weight of the everted gland or pressure exerted behind the gland by the eyeball.

Treatment. If it cannot be retained after it has been replaced in its normal position in the posterior cul-de-sac, carefully suturing it to the membrana might be attempted. Failing this it should be removed close to the posterior surface of the membrana by a sharp pair of scissors, after the seat of operation has been rendered insensible and bloodless by the use of a cocaine and adrenaline instillation.

Encanthis or a swollen condition of the caruncula lacrimalis is often seen in troop-horses. It is due to irritation set up by dust, flies, and other irritants.

Treatment consists in removal of the cause. General Smith advises eye-fringes as a preventive to the flies settling on the eyes.

Tumours of the membrana nictitans are not rare. In the horse carcinomata have been recognised (Fröhner, Poppe), recurring and necessitating the enucleation of the eye (Guerrieri), or secondarily invading the sublingual, pharyngeal or prepectoral glands (M'Fadyean); lipomata developed on the internal face of each membrana nictitans (Williams). Schimmel, and Over have described a dermoid situated in the membrana nictitans, conjunctiva and cornea of a calf; Harrison, an enchondroma and an epithelioma in the membrana nictitans of a dog. The special growths in this region are those developed at the expense of the Harderian gland, such as cysts in the pheasant (Larcher), adenomata in the horse (Ismert), and in the dog (Johne, Schimmel, Fröhner, Lewaschew). [?]

The *caruncula lacrimalis* may be invaded in the ox (U. Leblanc) by carcinoma, which may even occur in this animal in the form of actual enzoötics (Youatt,* Leo Löb); in grey horses melano-sarcomata (U. Leblanc). To the neoplasmata of the caruncula the term *encanthis* is applied; when they are merely papillary outgrowths or enlargements they are called encanthis benigna and when malignant, encanthis maligna. This terminology is, however, getting somewhat obsolete.

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* Youatt, *On Cattle*.

CHAPTER XVI.

THE LACRIMAL APPARATUS.

Anatomy and Physiology.

The principal descriptions of the anatomy of the lacrimal apparatus here given are taken from the works of Foltz (1862), Walzberg (1876), Kitt (1883), Ablaire (1906).

The apparatus comprises the lacrimal gland and the lacrimal passages.

The *lacrimal gland* is situated under the external half of the orbital arch between this and the eyeball, from which it is separated by the levator muscle of the upper eyelid and the superior rectus.

It is a lobulated gland, transversely elongated, and flattened from above to below; in the horse it measures about 6–7 cm. by 2 cm. From its anterior border, a little to the inner face, a number of small excretory ducts (*hygrophthalmic canals*) go to open a little in front of the depth of the superior cul-de-sac, or fornix conjunctivæ, of the conjunctiva. These are 12–15 in number, and from 1–1.5 mm. long in the horse. In the conjunctiva covering each eyelid near the external commissure, two or three small acinous glandular lobules, termed the glands of Krause or accessory lacrimal glands are found. In man these glands are found in the conjunctival fornix.

In the *ox* the lacrimal gland is better developed; it is thicker, distinctly lobulated, and divided into an upper or thick part and a lower or thin part. It has from six to eight hygrophthalmic ducts. In the *pig* the gland is of the mucous type. In the *dog* it is flat, pinkish in colour, mixed in structure, and is situated within the periorbita immediately under the orbital ligament. In birds the lacrimal gland is

in the form of a small roundish, reddish body resting upon the eyeball near the outer canthus, and opens upon the inner wall of the eyelids through a small slit.

The *lacrimal passages* comprise the lacrimal openings *(puncta)*, the lacrimal ducts, the lacrimal canal or nasal duct, and its nasal outlet.

The lacrimal openings (*puncta lacrimalia*), true elliptical fissures or slits in the horse, ox, and dog, are two in number, a superior and inferior (in the rabbit there is only one, the inferior); these fissures or puncta represent the conjunctival opening of the lacrimal passages. They are situated on the mucous face of the eyelids, near the re-entrant angle of their internal commissure and immediately over their free border.

In the horse the lower measures 2–3 mm. in its greatest diameter, the upper only 1–1.5. In man the puncta are very small and quite circular; in the pig the lower punctum and therefore the corresponding duct is frequently absent. In birds the two slit-like puncta enter a wide lacrimal canal which opens into the nasal cavity immediately above the inner nares.

The lacrimal ducts or *canaliculi*, also two in number, embrace the nasal angle of the eye like two arcs of a circle, their concavities looking inwards. They open on one hand by the lacrimal puncta on to the conjunctiva, and below into the upper part of the nasal duct, which is here dilated to form the lacrimal sac.

In the horse the lower duct or canaliculus is the shorter (1.5 cm.), but it is the broader (5 mm. in its greatest diameter near the sac). It is oval in section. The upper duct or canaliculus, circular in section, is about 2 cm. long and 4 mm. in diameter. Contrary to what is the case in man, in whom they unite to form a short common canal, they enter the sac separately.

In animals the lacrimal sac has neither the anatomical nor pathological importance that it has in man. Little developed in the horse and dog (5–8 mm. in diameter in the ox), it is simply formed by the widened upper extremity of the lacrimal canal.

The lacrimal canal of the horse, slightly inclined in the form of an S-shaped curve, is 25–30 cm. long and its average diameter is about 4–5 mm., but in its course it shows several dilatations, of which the most important, about 10 cm. from the nasal opening, is 1–2 cm. wide. It is, in about one-third of its course, hollowed out in the lacrimal and superior maxillary bones (*bony canal*); the rest is placed under the nasal mucous membrane (*membranous canal*).

Protected by the bony tube in which it is placed, the lacrimal canal is always gaping at its upper part. There is no valve near the sac as there is in man (Foltz). In the ox the nasal duct is short and almost straight. In the pig it is

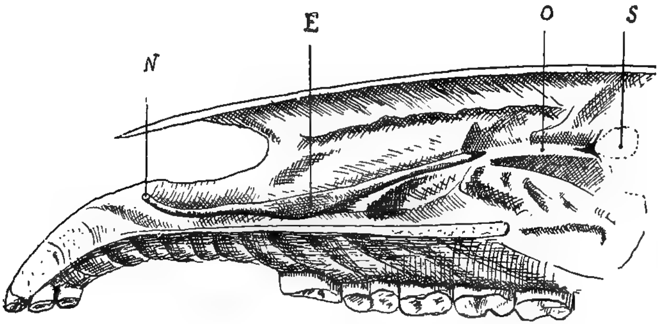


Fig. 155. Course of the Lacrimal Canal or Nasal Duct of the Horse. (Kitt).

S, Lacrimal sac ; *O*, the bony canal ; *E*, its dilated portion ; *N*, the nasal opening.

generally short. In the dog it is sometimes longer on one side than the other, and its free or membranous portion is often interrupted by one or more openings placed along its course.

The nasal or lower opening of the lacrimal canal is placed towards the inferior opening of the nostril; it is cut out as if with a punch, but does not gape. It is easily accessible in the horse, and is sometimes represented by two or several openings. In the *ass* and *mule* it is situated inside the external

wing of the nostril and not towards the inferior commissure as in the horse; in the *ox* it is deeply situated between two plates of cartilage in the inferior meatus, of the nasal fossa, and is not readily found; in the pig it is usually found in the inferior meatus at the posterior end. In the *dog* it opens sometimes inside and below the external wing of the nostril, sometimes in the inferior meatus of the nasal fossa, under the inferior turbinated bone (Chauveau, Arloing and Lesbre).

Structure. The mucous membrane of the ducts (canaliculi) is whitish and shows perpendicular folds; the epithelium is stratified, and pavemental. The mucous membrane of the sac and of the lacrimal canal is red, and the epithelium is cylindrical. The sac is surrounded by different layers of tissue which form the walls, such as the layers of small glands, of capillary lymphatics, and of fibrous tissue (Kitt).

Under normal conditions the lacrimal gland does not secrete more tears than are lost by evaporation from the surface of the eyeball, and in consequence there is no perceptible moisture at the nasal opening of the lacrimal canal. Besides keeping the eye moist the tears have another function; when the eye is irritated by dust, flies, fumes, etc., the lacrimal secretion is increased with the object of washing away the cause of the irritation. The tears actually seem to possess a bactericidal power. Valude, in inoculating pure cultures of the tubercle bacillus into the lacrimal sac of twenty rabbits, obtained no positive results, whilst inoculations always succeeded when the infective material was introduced into the cellular tissue of the conjunctiva out of reach of the lacrimal fluid. Its action is doubtless mechanical, the virulent products being washed away. The moisture of the eyeball and its appendages is, however, not solely due to the lacrimal gland as the various glandular and adenoid structures of the conjunctiva also contribute to this function. In support of this contention the eye does not become dry after the removal, destruction or degeneration of the lacrimal gland.

Epiphora and Lacrimation. The term *epiphora* is applied to the condition in which there is a flow of tears over the edge of the lower lid and down the face. Sometimes this condition is know as *stillicidium lacrimarium*. It may be caused by an obstruction to the course of the tears through the lacrimal passages; to a constriction or an obliteration of these channels; or simply to a deviation of one of the puncta.

This deviation is seen in all degrees of eversion (ectropium) or inversion (entropium) of the lower eyelid. It may, among other causes, be due to facial paralysis.

It is a common affection in some breeds of dogs, especially in the chow, the Maltese, and in those breeds which have a wide frontal region, a short narrow muzzle and a steep stop (junction of the frontal with the facial region). The hairs and skin in the naso-maxillary region of the face below the angle of the lower eyelid are constantly moist, and in those breeds, such as the Maltese, having white silky hair and a pink skin, the hair constantly moistened by the tears becomes stained a dark coppery or cinnamon brown colour.

When it is merely due to a simple or slight eversion of the lower eyelid it may be removed by slitting up the inferior canaliculus. If it be the result of an ectropion of a greater degree, or of an entropium, the deviation of the lower lid should be remedied so as to bring the inferior punctum into its proper relation with the eyeball.

Lacrimation is used to denote an increased secretion of tears which is often seen accompanying irritation or disease of the eyeball or of the conjunctival or other membranes. The tears form so rapidly that the lacrimal passages cannot carry them away fast enough, so that they trickle over the eyelid.

Lacrimation may be produced by wind, dust, foreign bodies in the eye or conjunctival sac, congestion and catarrh of the conjunctival membrane accompanying infectious diseases, periodic ophthalmia, corneal ulcer, etc. The term epiphora is often used synonymously with that of lacrimation, and *vice versâ*.

"*Weeping*," sometimes, but erroneously, used in veterinary medicine to denote the above condition, is a physiological process, also known as "crying." This is rarely seen in the domesticated animals. Gray, however, has observed it in the cat when suffering from *nostalgia* (home-sickness).

Absence or *abolition* of the *lacrimal secretion* is due to disease of the lacrimal gland or to a dry lustreless state of the cornea, accompanied in its advanced forms by shrinking of the deeper layers of the corneal membrane and known as *Xerosis* or *Xerophthalmos*; or to occlusion of the excretory (hygrophthalmic) ducts of the lacrimal gland, in consequence of the latter condition; or to paralysis of the 5th, or to paralysis of the 7th arising from some cause situate within the brain.

Both "Weeping" and the opposite condition—absence of tears are, in man, usually due to emotional causes such as grief or mirth.

Dacryoadenitis or Inflammation of the Lacrimal Gland. This is occasionally seen in the horse affected with strangles. The gland swells, the conjunctival surface of the upper lid becomes hyperæmic and very much swollen (chemosis) and after a time pits on pressure, and eventually the skin over the eyelid bursts and gives rise to an issue of pus from one or more openings. If allowed to open spontaneously the suppurative process quickly terminates and there is no more trouble. If, on the contrary, suppuration is assisted before the abscess commences to point, a subacute or even chronic inflammation of the gland, together with one or more fistulæ, results.

The lacrimal gland may also be affected with *tuberculosis*, with *neoplasmata* such as carcinoma, sarcoma, adenoma, lymphadenoma, with a cystoid dilatation of the ducts of the gland, and further, may undergo atrophy. Some or all of these abnormal conditions may be seen in the dog, cat and other domesticated animals, and when present the gland should be extirpated.

Extirpation of the Lacrimal Gland. This is performed in the horse in cases of chronic persistent lacrimation after

all other methods of treatment have proved useless. Starting from the middle line of the upper eyelid, incise the skin towards the outside, following a curved line about 6 cm. in length, parallel to the anterior border of the orbit and a little in front of it. Penetrate between the orbital rim and the aponeurosis of the levator palpebræ superioris, dissect down to the gland, seize it with flat-ended forceps and excise it with a bistoury or with scissors. The wound should then be dried, sutured, and covered with collodion (Cadiot).

Obstruction of the Lacrimal Passages. In the horse this is almost the only affection of the lacrimal apparatus of which data exist.

The obstruction may be *congenital*, and usually consists in the nasal opening being imperforate. *Acquired* obstructions are sometimes seen. Professor Macqueen's experience is that the latter occurs more frequently than the former.

Nicolas in one case, in making a post-mortem examination of a horse, found the superior punctum to be imperforate; this did not seem to have produced any symptom in the animal during life.

Congenital Imperforation of the Nasal Opening of the duct has been noticed by Nicolas a great number of times in foals a few days old, once even in a colt two years of age (Mauri).

The tears not being able to escape by the nostril fill up the lacrimal canal and the canaliculi and overflow by the puncta.

As they become stagnant they decompose and become irritant, like every organic liquid. The overflow brings down with it muco-pus, coming from the lacrimal passages as well as from the conjunctiva, which soils the skin below the internal angle of the eye, causes the hair to fall out and leads to erythema of the region. These symptoms persisting in young animals attract attention, and absence of the nasal opening is discovered. In its place is a prominence which yields to pressure and gives the impression of a blind tube distended with liquid. An opening can easily be made with a small knife. Injections of warm boracic solution, or simply of boiled water, will maintain the patency of this artificial

opening, and in a few days all trace of the irritation of the conjunctiva will have disappeared.

In Mauri's case intervention was not so simple, as the imperforation was double, and inaccessible from the nostril. On account of its deep situation from the culs-de-sac he was obliged to trephine above the root of the first molar to reach the nasal duct, and then having opened it he introduced a probe as far as the cul-de-sac, perforated it, and passed a seton which he kept in place for ten days.

Acquired Obstruction is not uncommon, especially in troop-horses in hot weather. The dust of the roads and manœuvering grounds is the most frequent cause. Several animals are attacked at the same time and often in both eyes; they show photophobia, epiphora, the tears bringing down filaments of mucus mixed with dust or sand and therefore greyish in colour.

The nasal opening of the canal is obstructed by thick mucus or by the above mentioned filaments mixed with dust.

Nicolas has never met with a case of lacrimal tumour *(mucocele)* due to the repletion of the sac causing it to become inflamed, though the condition is seen in man. It is, however, occasionally seen in the cat and dog.

Another reported cause of obstruction is the penetration of spikelets of grasses, and other foreign bodies into the nasal opening in the ass and mule.

No mention of cicatricial constrictions of the mucous membrane, or of compression by tumours in the neighbourhood causing obstruction, can be found in veterinary literature.

Diagnosis and Treatment. Lacrimation ought always to direct attention to the nasal opening of the canal, if it cannot be at once explained by other causes. The presence of a mucous or muco-purulent plug at the edge of the opening should suggest an inflammatory obstruction due to dust or to some irritant body.

In any doubtful case the following procedure, which will be

given at length, should be resorted to ; it is as much a method of treatment as of diagnosis.

Irrigation of the Lacrimal Passages. The wide opening of the nasal duct at both its extremities, the inferior punctum above and the nasal opening below allow the whole apparatus to be irrigated from above to below or in the reverse direction. The first is called *lacrimo-nasal* or the

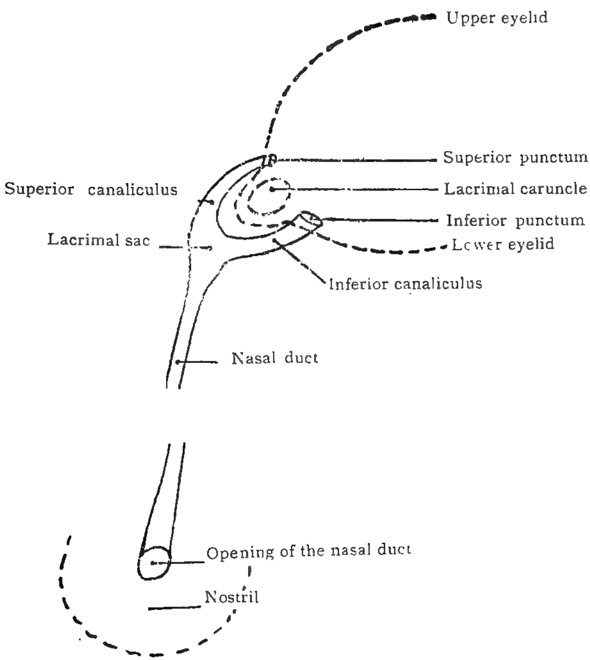


Fig. 156. Diagram of the lacrimal passages of the horse to illustrate the methods of irrigation and of catheterization.

direct, and the second *naso-lacrimal* or the *retrograde* method. As in dealing with all cases requiring manipulation of the eye and its appendages, it is necessary to place the animal as completely under control as possible.

Lacrimo-nasal or *Direct Irrigation.* This is a delicate operation on account of the danger of wounding the eye.

It is practised from the inferior lacrimal punctum, in which the end of a fine canula of a hydrocele syringe may be placed. In man, however, the small size of the lacrimal openings, the bend in the canaliculi, almost a right angle, makes it necessary to enlarge the inferior punctum with a Weber's knife (Fig. 157).

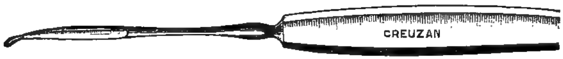
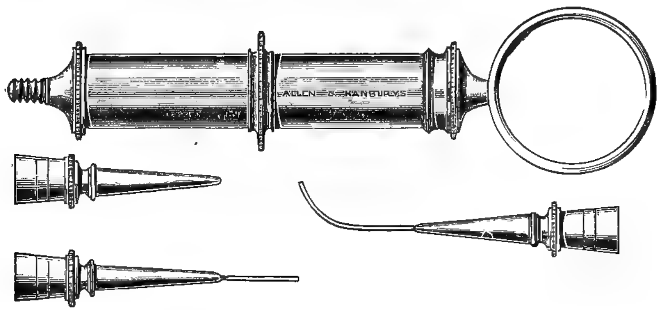


Fig. 157. Weber's canaliculus knife.

Anel's syringe has been recommended for use in veterinary practice. Nicolas considers that any syringe fitted with a fine detachable point, so that it can be used with one



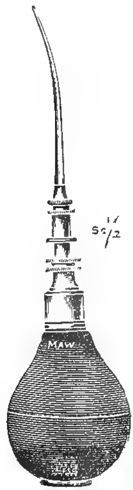
Anels' lacrimal syringe for cat and dog.

hand, is suitable. But it must be of sufficient size (about 200 cubic centimetres) in order that a complete irrigation may be made.

A few drops of cocaine having been previously instilled into the eye, turn the internal edge of the lower lid outwards with the fingers and make certain that the inferior lacrimal punctum is permeable. In horses which strongly contract the orbicularis, this is sometimes difficult to see, because it is not gaping, its lips being closed like a valve.

With the hand which manipulates the syringe, the end of the canula is introduced into the cleft and directed in such a way that it points towards the nasal angle and slightly downwards. The liquid injected, which must be warm and non-irritant (boiled water, solution of boracic acid, sublimate or formol 1 : 4000, or cyanide of mercury 1 : 2000) and forced in gently, will soon run out of the corresponding nostril if the lacrimal canal is free, or only from the superior lacrimal punctum if the obstruction is complete. But there are cases in which there is only a slight constriction of the canal, and if the injection is forced in too rapidly, the liquid squirts out by the superior punctum as well as from the nasal opening.

From a diagnostic point of view, lacrimo-nasal irrigation enables it to be determined whether the canal is obstructed or is permeable to liquids, but it cannot enable the degree of permeability to be exactly stated, or in other words the presence or absence of a *stricture* cannot be discovered.



Bowman's lacrimal syringe for cat and dog.

Lacrimo-nasal, or direct irrigation is difficult to perform in comparison with naso-lacrimal or indirect, which will now be described; but it is sometimes necessary to make use of it, when the nasal opening is placed so high that it is not easily reached from the nostril; also when there are several openings one above the other at the lower end of the canal, it is then necessary to inject the liquid at the highest opening. This method is also to be used in the ass, mule, cat and dog, in which the nasal opening is not accessible.

Naso-lacrimal or *indirect irrigation*. This is much the more convenient procedure. As it is essentially veterinary it is not merely the result of a process of imitation. Nevertheless, it is not of recent date, since Vegetius Renatus (450-510 A.D.), recommended the introduction of a small canula into the

lacrimal canal and to blow into it a mouthful of good wine. Percivall had already adopted (1841) this method before Möller and Vachetta mentioned it as being the most practical. In Great Britain it seems to have been the usual procedure for a long period, no doubt in consequence of the teachings of Percivall. French authors seem to ignore it, but in spite of this it is used by practitioners, probably for the first time by Coulon, vétérinaire en premier, in 1894. In 1902 Ablaire gave a description of it.

One hand holding the wing of the nostril apart as if for examination and the other firmly grasping the syringe, which should be provided with finger rings, the end of the canula is introduced into the nasal opening parallel to the mucous membrane. Then without pressing the edges of the opening the liquid is gently forced in.

Instead of directly introducing the canula of the syringe into the opening, a gum-elastic catheter may be introduced into the nasal opening and the injection given through this. Unless the tube or catheter can be screwed on to the syringe, Nicolas advises the use of the canula direct, as otherwise the least movement on the part of the horse causes the tube to fall. The nasal orifice, being sometimes very small, it is always well to have a probe-pointed or Weber's knife at hand with which to slit up the opening if necessary. An ordinary bistoury exposes the lower wall of the canal and the wing of the nostril to some danger and should not be used.

When the canal is free the liquid can be seen to run out of the lacrimal puncta and in some cases it forms two jets.

When the canal is obstructed by mucus or dust, the finger on the piston of the syringe is sensible of a resistance which must not be forcibly overcome, even if it were possible. Withdraw the canula and allow the liquid injected to trickle out by the lower opening. It usually brings with it portions of the mass of mucus which is obstructing the canal more or less completely. Then again commence injecting the canal and repeat the process until the lumen is quite free from obstruction, which will be indicated by the liquid running out

of the angle of the eye and bringing with it particles of mucus.

In cases in which the canal cannot be completely cleared of the obstruction at one attempt, which is rare when the trouble is recent and caused by dust, etc., the irrigation must be repeated the following day.

The distension of a portion of the membranous part of the canal by the pressure of the injection is unavoidable if there is an obstruction; it may cause small hæmorrhages, which are of no consequence at the time or afterwards.

Naso-lacrimal injections cause a particular resistance on the part of animal which hinders the movements of the surgeon considerably; the end of the nose is contracted to one side, very vigorously, and this moves the syringe and pushes the canula out of place. An assistant should hold both the nose and the syringe to prevent this happening.

Lastly the flow of the liquid over the pituitary mucous membrane usually causes snorting, against which it is best to guard by holding the upper wing of the nostril down, by standing on one side, and by wearing a smock.

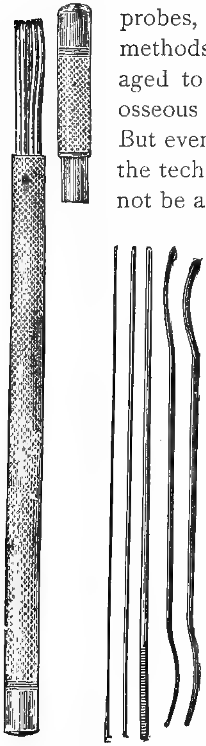
In place of a syringe any other means of injection may be used; a Higginson's syringe as used for vaginal injections, which has an aspirating as well as a forcing effect, as used for nasal injections in man, etc.

Catheterization of the lacrimal passages. The introduction of a sound or a bougie into the nasal duct of the horse is not possible if the instrument be made of any stiff material. With a flexible catheter it is quite possible; according to Professor Macqueen, quite easy. The flexible metal catheter used in human bladder surgery for catheterization of the ureters is very suitable. Nicolas in this matter cannot agree with many other authors who consider the operation impossible.

Passing a rigid sound being the only method used in the human subject it was naturally the first to be thought of in veterinary practice.

But here the difficulties are numerous and evidently result

from the anatomical formation; the length of the lower lacrimal canaliculus, 2 centimetres, its insertion into the osseous lacrimal canal almost at right angles; the great length of the bony canal itself, 25–30 cm., and especially its winding course. Bayer nevertheless speaks of Bowman's probes, and Ablaire, almost exactly following the methods used in human ophthalmology, has managed to introduce curved knitting needles into the osseous portion of the lacrimal canal in the horse. But even if the operation were relatively easy, and the technique as well known as in man, it would not be advisable in veterinary practice because it is incomplete and may create false routes. The introduction of Bowman's metal probes is somewhat too barbarous to be commonly used in human practice and its use is not warranted in animals, unless, perhaps, in the cat and dog. On the other hand the catheterization of the lacrimal passages by means of a flexible catheter is easy, and can be practised from above downwards (lacrimo-nasal or direct) or from below upwards (naso-lacrimal or retrograde). Leblanc, in 1824, made use of this method by means of a whalebone probe. Fine long filiform whalebone sounds may be obtained for this purpose. Percivall as far back as 1841 had suggested the use of the gum-elastic catheter for this purpose. Flexible bougies should be used, similar to those employed for exploring the urethra. They should be about 40 cm. long and may be made with double olivary ends. Under normal conditions the lacrimal canal will allow the passage of No. 7 and 8 filiform bougies (French gauge). In whatever direction they are to be used, a few drops of solution of



Bowman's lacrimal probes for cat and dog.

cocaine should first be instilled into the eye and then the bougie should be lubricated with a cocaine ointment (1 : 100 of vaseline). No force should be used for fear of damaging the delicate lining membrane of the canal.

Direct or *Lacrimo-nasal Catheterization.* Introduce one of the olivary extremities of the bougie into the inferior lacrimal punctum, with the right hand in the case of the left eye, with the left hand for the right eye, the fingers of the disengaged hand being used to slightly evert the lid. Push the bougie gently in the direction of the caruncula. It soon touches the osseous wall of the sac; the resistance of the wall soon disappears on making some rotatory movements of the bougie between the fingers, and the sound enters the bony portion of the lacrimal canal. By carefully pushing it onward and taking notice of the length of the bougie introduced, it can be made to emerge at the lower or nasal opening. It is necessary to proceed with care, or the end of the instrument may become caught in a fold of the lining membrane and bent on itself, and is thus easily spoilt. A finger of the hand which is not engaged in manipulating the bougie may be placed over the nasal opening to feel for and assist in directing the exit of the end of the bougie. The instrument is then withdrawn from one end or the other.

It may happen, but rarely, that the bougie cannot be made to enter the lacrimal canal. In this case the other method may be tried.

Retrograde or *Naso-lacrimal Catheterization.* The introduction of the bougie by the nasal opening is most simple, but it is rare for it not to become caught about 10 cm. from the nasal end, doubtless by a fold of the mucous membrane mentioned by Ablaire as occurring at the entry to the dilatation of the canal. After a few gentle and careful movements of the hand it may be possible to free the end from this obstruction; this done, the catheterization is completed without difficulty, but here again it is necessary to watch for the exit of the bougie. Its arrival at the angle of the eye is announced by frequent and considerable movements of the

third eyelid which seems to try to form a defence against the intrusion of the foreign body; these are overcome and the sound appears, at the upper lacrimal punctum as a rule, but sometimes at the lower.

Lacrimal Tumour, Dacryocystitis, and Lacrimal Fistula.

In man obstruction of the lacrimal canal is accompanied by repletion and dilatation of the sac (*lacrimal tumour* or *mucocele*), of inflammation of the mucous membrane and of the submucous tissue which leads to the formation of a suppurative condition of the areolar tissue (*dacryocystitis*). Lastly, this may sometimes open externally, and in so doing create a fistula from which the tears escape (*lacrimal fistula*). The deep situation of the lacrimal sac renders the existence of a visible lacrimal tumour very unlikely. It has, however, been mentioned by Bayer and Wolff; but Nicolas has never met with a case, although he has often had to intervene in cases of obstruction of the nasal passages. Gray has, however, seen the lacrimal sac in the cat and dog the seat of a chronic catarrh, which has given rise to a profuse flow of tears over the skin of the face, and caused excoriation and loss of hair.

On inspection of the region of the lacrimal sac, which is better protected by its bony surroundings in some breeds than in others, in the neighbourhood of the inner canthus the skin is found bulging or protruding to such an extent as to make this region appear larger than that of the opposite eye. When pressure is brought to bear upon it, its contents are pressed out through the puncta. If of recent origin the discharge is purulent, but watery in appearance when of some standing.

Gray has also seen acute *inflammation of the lacrimal sac* somewhat suddenly develop in the cat and dog. The skin over the region appears swollen, reddish or purplish, and shiny; after a short period this ruptures, leaving a hole which gives exit to a quantity of blood-tinged, yellowish pus and eventually this is followed by the disappearance of the

swelling; but the discharge becomes changed from purulent to a mucous and ultimately to a watery one.

If the perforation remain, nothing but tears, which overflow from the lacrimal sac, pass through it. Hence a fistula results.

The *treatment* of lacrimal catarrh and dacryocystitis and the consequent lacrimal fistula consists in, at first, injections of warm, mild antiseptic solutions by means of a fine probe-pointed syringe, such as Anel's or Bowman's, and afterwards in the passage of fine gum elastic or celluloid probes in preference to the metallic ones of Bowman. If this fistula still remain it may be advisable to slit open the lower canaliculus and the sac, and afterwards treat it as an open wound.

Small resistant tumours resting on the bone a little below the internal angle of the eye are sometimes met with in the horse, but they have no relation to the lacrimal canals as can be seen by pressing on them with the fingers, for they do not shrink and are not emptied by the lacrimal puncta; they are in fact sebaceous cysts. Nicolas has not seen either dacryocystitis or lacrimal fistula. Certain cases of fistula in the dog and cat, opening near the internal angle of the eye have their origin in caries of bone commencing in the teeth (Möller); and other diseased conditions of the antrum of Highmore seen not only in the dog, but also the cat and mongoose. When due to suppurative periodontitis or necrotic inflammation of the root of the tooth, the fistula commences, as a rule, to disappear as soon as the offending tooth is extracted.

Diagnosis. The position of a *dental fistula* differs, however, from that of a *lacrimal fistula.* A lacrimal fistula is a little below and slightly in advance of the inner canthus; whilst dental fistula is much more inferiorly and posteriorly situated, in fact, it is situated immediately on a level with the root-apex of the carnassial, sometimes the precarnassial or the first molar, tooth—this being the most dependent part of the superior maxillary sinus in the cat, dog and mongoose.

CHAPTER XV.

MOTOR APPARATUS.

Anatomy.

The motor apparatus of the eye is made up of seven muscles: four straight muscles, two oblique, and one choanoid, retractor, or posterior straight muscle, to which may be added the levator of the upper eyelid.

Levator of the upper eyelid (Levator palpebræ superioris). This is a thin muscle deeply inserted near the optic foramen with the other motor muscles of the eye; it is directed towards the rim of the orbit, and placed above the superior rectus with which it has some aponeurotic connections. In front it has two insertions, one, which is mobile, takes place through the medium of a broad aponeurosis, to the tarsus of the upper lid; the other, fixed by means of two slips to the anterior and posterior angles of the orbital rim (Motais).

Owing to this fixed attachment the retraction of the muscle is limited, and the raising of the upper lid is accompanied by an upward movement of the eyeball.

Four recti or straight muscles. These are inserted posteriorly round the optic foramen and the sphenoidal fissure, and they are directed towards the eyeball in such a way as to occupy the four cardinal points. Their insertions into the sclerotic, very well shown by Motais, are given in figs. 158 and 159 in the horse and dog. It can be seen that their points of insertion are at varying distances from the cornea and that they also vary in extent and direction.

Actions. In the horse according to the direction of their fibres the superior-internal, and external recti have a direct action; the first elevates the pupil and the others adduct or abduct the eye respectively. The inferior rectus alone seems capable of lowering the pupil and rotating it inwards (Motais).

In the dog the action of the straight muscles seems to be the same as in man, that is to say, the internal rectus is an adductor and the external an abductor; the superior rectus raises the eye and rotates it inwardly; the inferior rectus lowers and slightly rotates it outwards.

Aponeurotic connections. The connection of the superior rectus with the levator of the upper lid has already been

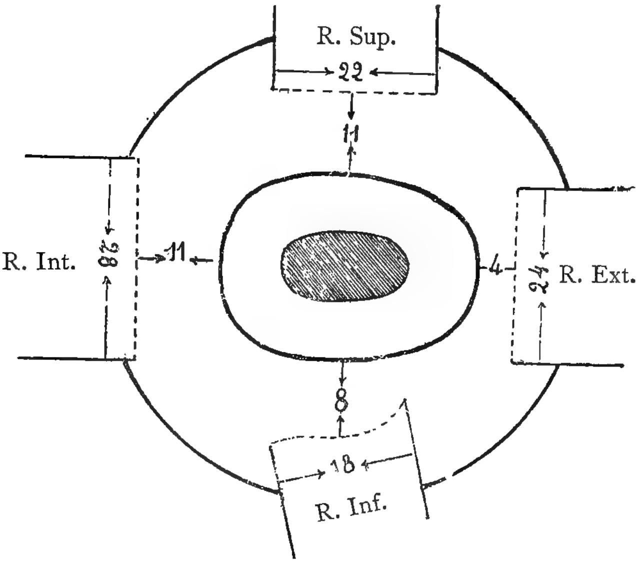


Fig. 158.—Insertions of the recti muscles of the eye of the horse into the sclerotic. (The figures give the measurement in millimetres).

mentioned, so has the fact that the raising of the pupil entails the raising of the upper lid; the inferior rectus is connected with the lower lid, so that this last muscle contributes to the lowering movement of the inferior lid, but in the horse, movement is almost *nil*.

Oblique muscles. These are two in number, the great or superior oblique, and the small or inferior.

The *superior oblique* goes from the optic foramen and follows the internal osseous wall of the orbit between the superior rectus and the internal rectus, and is bent on itself by means of a "pulley" to reach the globe in quite a different direction to that in which it starts. The first portion is called *direct*, the second the *reflected*.

The "*pulley*" is a fibrous band fixed by its extremities to the frontal bone at the supero-internal angle of the base of

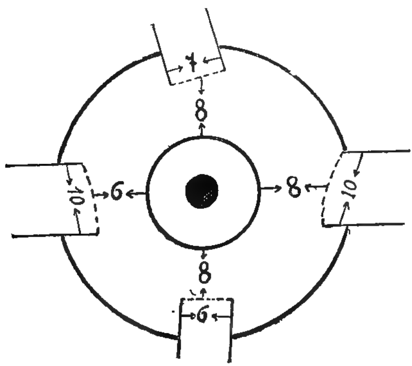


Fig. 159.—Insertions of the recti muscles of the dog into the sclerotic. (Arranged as in the preceding figures).

the orbit, and forms, with a depression in the bone situated beneath it, a gliding surface, through which passes the superior oblique muscle and round which it is reflected on to the eyeball.

It is situated about two, three or four centimetres from the rim of the orbit in the horse and in ruminants, is a little nearer to it in the carnivora, and a few millimetres further away in man (Motais). (*See* fig. 160).

The *reflected portion*, largely muscular in the horse and in ruminants, is entirely tendinous in the carnivora, and in both cases it is attached to the anterior hemisphere of the globe outside the superior rectus under which it passes. In man the scleral insertion of the great oblique is upon the posterior hemisphere.

The *inferior oblique* has only one, more or less, transverse portion corresponding to the reflected portion of the superior muscle. Its fixed insertion is into the infero-internal angle of the base of the orbit beneath the lacrimal fossa, 15–20 millimetres from the rim of the orbit in the horse, and 7–8 in the dog; but quite close in man. It penetrates under the eyeball, passes to the surface of the inferior rectus and is *attached to the sclerotic* outside this muscle, on the anterior hemisphere in the horse and dog and on the posterior in man. Strangeways has described a *supernumerary oblique muscle* found occasionally in the ass, between the small and great oblique muscles.

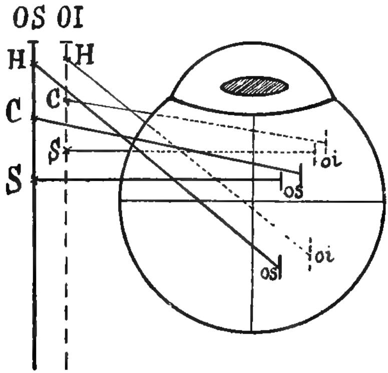


Fig. 160.—Comparative insertions of the oblique muscles. *HH*, In man. *CC*, In the dog. *SS*, In equines and in ruminants. *Os*, Points of insertion of the superior obliques. *Oi*, Points of insertion of the inferior obliques.

Direction and action of the oblique muscles. In equines and in ruminants the direction of the oblique muscles in relation to the antero-posterior axis of the eye is almost transverse; it becomes slightly oblique in forward direction in the carnivora on *account of* the advancement of the insertion. In man they are fixed very obliquely from before backward for

the double reason that their fixed points are still more anterior and their scleral insertions are on the posterior hemisphere (Motais). *See* fig. 160.

These then are simple rotators of the eye in equines and ruminants: the superior oblique rotating inwards and the inferior oblique rotating outwards; in man they have two other actions: the great oblique displaces the cornea downwards and outwards, the small oblique displacing it upwards and outwards.

In the dog the oblique muscles principally play the part of rotators. It seems that by contracting together they have the effect of carrying the eyeball forward and making the cornea more prominent between the lids (Kalt). Strangeways thinks the *supernumerary oblique muscle* sometimes found in the ass acts as an accessory or check muscle of the superior oblique, and is "placed there for the purpose of preventing the belly of that muscle becoming fixed in the loop through which it has to pass at such an acute angle."

Choanoid or *retractor muscle*. This is also called the posterior rectus, and exists in almost all the mammalia except in man and the ape. It owes its name "choanoid" to its funnel shape, which is especially clear in ruminants, in which the muscle is most developed. In the majority of carnivora and in some reptiles it consists of four distinct portions simulating the four recti muscles and does not, as in ruminants, form a funnel. Taking origin round the optic foramen and from the interior of sphenoidal canal, it is inserted into the sclerotic, following an irregularly circular line behind the recti and oblique muscles, and having some aponeurotic connections with the latter.

It acts as a *suspensory muscle* to the eyeball when the head is inclined forward, and as a powerful *retractor*, this leading to the protrusion of the membrana nictitans. According to H. Müller the retraction of this latter organ depends to a certain degree on some unstriped muscles of the eyelids and of the periorbita which are under the influence of the sympa-

thetic. In the hare, the retraction is due to striated a muscle, which is supplied by the common oculo-motor.

The connections of the muscles of the eye between themselves, with the capsule of Tenon, and with the walls of the orbital opening (Fig. 161), allow the eyeball to move in its place around a fixed centre.

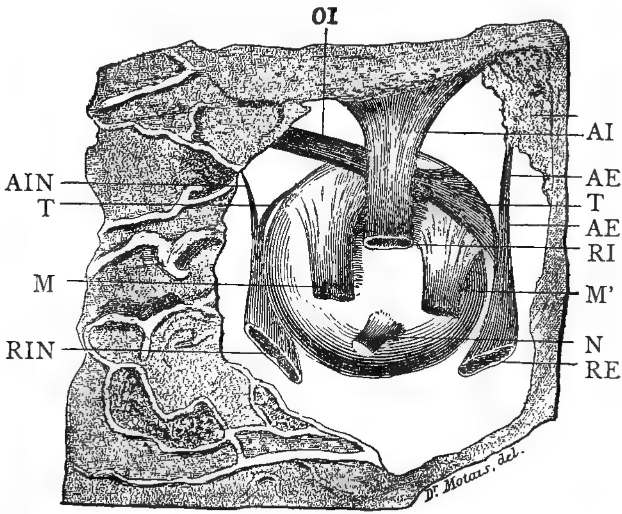


Fig. 161. Orbital tendons of the recti muscles of the dog (Motais).

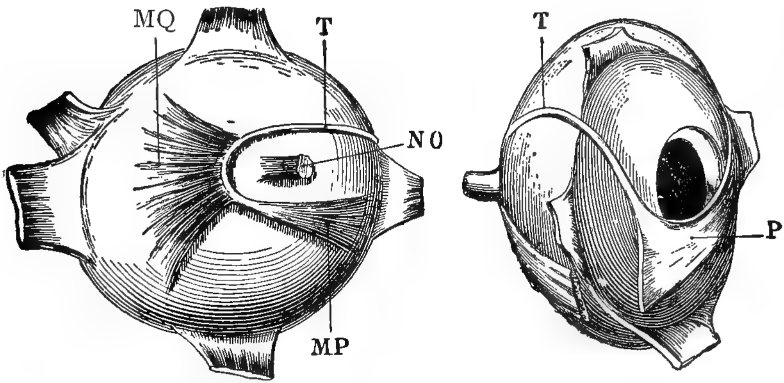
RIN, Internal rectus; *AIN*, its orbital tendon, internal slip. *RI*, Inferior rectus; *AI*, Its orbital tendon, inferior slip. *RE*, External rectus; *AE*, external slip. *OI*, Inferior oblique. (*Encyclop. franç. d'ophtalm.*)

The relation between the displacements of the cornea and those of the papilla, in strabismic deviations of the eye, allow the *point of rotation* on the ocular axis to be fixed, in the horse, between the centre of the lens and the posterior capsule (Ballangée).

Square and pyramidal muscles. These muscles, which only

exist in birds, saurii, etc., move the membrana nictitans. A good idea of them can be obtained from Figs. 162 and 163.

Innervation of the muscles of the eye. It is important to remember that the nerves of the extrinsic muscles of the eye (those above dealt with), and the intrinsic (the sphincter of the pupil and the ciliary muscle or the muscle of accommodation), come from three sources: (1) The *common oculo-motor* (3rd cranial), which directly supplies the levator of the upper



Figs. 162 and 163. Motor muscles of the membrana nictitans in birds. (Motais, *Encyclop. franç d'ophtalm.*)

MQ, Square muscle. *MP*, Pyramidal muscle. *N*, The optic nerve. *P*, The membrana nictitans. *T*, Tendon of the pyramidal muscle.

eyelid, the superior, internal, and inferior recti, the inferior oblique, and indirectly through the ophthalmic ganglion, the sphincter of the pupil and the ciliary muscle; (2) the *external oculo-motor* (6th cranial), which goes to the external rectus, and the retractor or choanoid muscle, and in birds the square and pyramidal muscles; (3) the *pathetic* (4th cranial), going to the superior oblique.

For the sake of completeness it may be mentioned that the orbicular muscle of the eye is supplied by the *facial* (7th cranial), and the dilator of the pupil, the muscular fibres of

the periorbitale or orbital membrane and Müller's unstriped muscles, by the *sympathetic*.

Nerve centres of the motor nerves. The movements of the muscles of the eye are regulated by nervous centres of various orders.

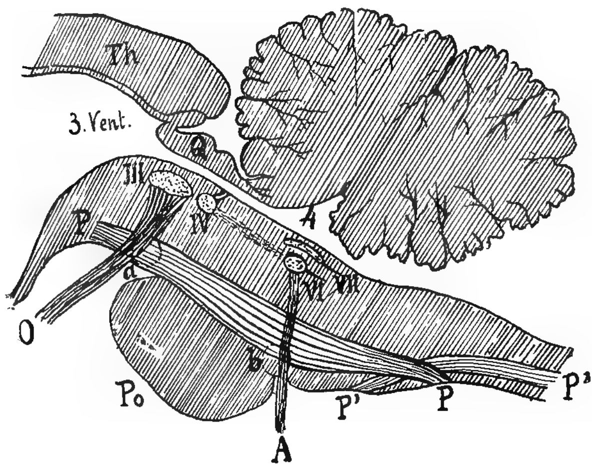


Fig. 164. Nuclei of origin of the motor nerves of the eye. Diagrammatic antero-posterior section of the isthmus of the brain of man. (After Fuchs).

III, Nucleus of the common oculo-motor, situated below the anterior pair of corpora quadrigemina, *Q*. *O*, The nerve trunk of the common oculo-motor, originating at the anterior border of the pons Varolii, *Po*. *IV*, The nucleus of the pathetic, the fibres of which are directed to emerge on the other side. *VI*, The nucleus of the motor oculi externus situated in the floor of the fourth ventricle (4), immediately beneath the nucleus of the facial (*VII*). *A*, Trunk of the motor oculi externus. *P*, *P*, *P'*, *P'*, Right and left pyramidal fasciculi crossed. *Th*, Thalamus.

A lesion at *a* will produce an alternating paralysis of the 3rd pair and of the extremities, and a lesion at *b* will produce an alternating paralysis of the external oculo-motor, and of the extremities.

The centres of voluntary movement situated in the cortical layers of the brain. The situation of the *centres of association* which cause the left internal rectus and the right external rectus, for example, to act together to produce a look towards the left, has not yet been certainly determined. The *bulbar centres* or nuclei of origin of the nerves supplying the muscles of the eye are the best known. They go in pairs and are situated under the aqueduct of Sylvius and in the floor of the fourth ventricle, on each side of the middle line. A study of the accompanying diagram (Fig. 164) will show their situation and relations better than a long description.

It may be added that the nucleus of the common oculo-motor is formed of several partial nuclei which up to a certain point are independent, and each one deals with the muscles innervated by the 3rd pair. In the dog these centres have the following situation from before backward: the ciliary muscle, the sphincter of the iris, the internal rectus, the superior rectus, the levator palpebræ superioris, the inferior rectus, and the inferior oblique. The same holds good for man, at least as far as the relationship of the first three is concerned and this explains the association of the three movements: convergence, pupillary contraction and accommodation.

Path of the motor nerves. In the pons Varolii the common oculo-motor and the oculo-motor externus as well as the facial have a direct tract, whilst the pathetic or nerve of the superior oblique has a crossed tract. As the diagram shows, the direct bulbar tract of the 3rd, 6th, and 7th pairs have relations with the pyramidal fasciculi, which are themselves crossed in such a way that the same lesion may produce ocular and facial paralysis on one side as well as paralysis of the limbs on the other (*alternating paralysis*). Hébrant has seen interesting examples of this in the dog.

Outside the pons Varolii the common oculo-motor (3rd), and the oculo-motor externus (6th) reach the great sphenoidal fissure, where they join with the ophthalmic branch of the trigeminal (5th) before reaching the orbital

hiatus. The pathetic (4th) passes through the pathetic canal (which is exclusively reserved for it) before it reaches the ocular sheath.

It may be added that the facial (7th), which is near the abducens (6th) in the pons, is not related to it outside the cranium. It reaches the internal auditory canal to go out by the stylo-mastoid foramen, beneath the parotid.

For a further consideration of this subject see *Smith's Veterinary Physiology*, 4th Edition.

Strabismus. Under this heading, which is used in its widest sense, all the abnormal deviations of the eye will be included. In man two forms of strabismus, a paralytic and a non-paralytic are distinguished; the non-paralytic form is also called concomitant and is due to a functional disturbance of the apparatus of binocular vision.

The etiological outline which is used in describing this disease in animals, in no way reproduces the large division of human ophthalmology, and the forms which in veterinary practice are considered as non-paralytic cannot be referred to functional strabismus as it is known in man.

Symptoms. Direction of the deviation. Theoretically three general abnormal directions can be conceived and recognised by the direction of the pupil: (1) deviation of the pupil in the vertical meridian (upwards or downwards); (2) deviation of the pupil in a horizontal meridian (inwards or outwards, or towards the nasal or temporal angles); (3) deviation of the pupil in one of the oblique meridians. In fact the following forms of strabismus have been observed in animals: inferior and superior vertical strabismus, convergent and divergent horizontal strabismus, and the form which may be called composite, which is not included in the above varieties.

Diagnosis of the direction of the deviation. This is easy in man, in which the direction of the visual axes is parallel. The deviation is also striking in the dog and cat in which the eyes are almost in the frontal plane; but in the horse and other animals in which the eyes are placed more laterally, the two eyes must be compared with each other,

taking into consideration some fixed landmark, as it is quite easy to be mistaken by appearances.

Vertical strabismus is most easy to diagnose by taking the superior and inferior margins of the cornea as landmarks on the eye itself, and as the fixed points the margin of the lower eyelid and of the upper part of the rim of the orbit. One other very interesting mark is the situation of the papilla.

In the normal state, in the horse, *the lower eyelid covers the whole of the sclerotic below the cornea and its margin touches or nearly covers that of the cornea.* So that if, for example, the cornea is separated from the lower eyelid by an appreciable border of the sclerotic, which cannot be seen on the other side, there will be superior strabismus on this side.

On raising the upper eyelid with the index finger as far as the rim of the orbit, as if to examine the conjunctiva, on the affected side a band of the sclerotic, broader or more narrow than that of the normal side will be seen.

Lastly, in the affected eye, the papilla on ophthalmoscopic examination is deviated from its normal position in a direction opposite to that of the strabismus. Situated normally slightly beneath the horizontal meridian, it is found above this in inferior strabismus, whilst in superior strabismus it is sometimes so far below that it is only possible to see a small segment of it. This very striking sign has several times attracted the attention of Nicolas, Clerget and Fayet in cases of strabismus which otherwise would have been ignored. It has also been seen by Bayer, and Ballangée.

In *horizontal strabismus* the diagnosis is made by comparison of the amount of sclerotic visible in the nasal and temporal angles with that of the opposite eye. The relative position of the pupil is also noted, as it may be more or less hidden in one of the angles of the eye. Further, the papilla may be displaced towards the nasal or temporal side. This should not be confounded with the normal *apparent squint* observed in the horse when he directs both eyes forward in looking at an object in front of him. In the cat and dog, bilateral convergent squint is frequent, whereas divergent

squint in the former animal is very rare, and in the latter infrequent, and then not rarely single. The divergent squint is seen chiefly in the intensely in-bred pug, and the toy spaniels.

Lastly, in *intermediate strabismus* diagnosis is chiefly based on the direction of the major axis of the pupil with regard to the horizontal and to a central line joining the commissures of the eyelids.

Symptoms associated with strabismus. (1) *Deviation of the head.* The deviation of the head, especially in a vertical and transverse plane, so that the end of the nose is inclined in one direction while the top of the head is inclined towards the other, as in torticollis, is sufficiently constant in vertical strabismus to have struck Mauri, Peters, Bayer, Ballangée, and Clerget, Fayet and Nicolas, all of whom have observed this apparent form in the Equidæ. Dor has seen it in the rabbit, and Gray in the dog. It is intermittent, and is more marked when the animal seems to fix its attention on some object, as, for example, a horse in a loose box looking out of the half-opened door.

The direction of the deviation of the head seems to have a fixed relation to the direction of the strabismus. Inferior strabismus of one side seems to deviate the head to the other side; this disposition has been observed in one case by Ballangée, one by Dor, another by Dollar,* and four by Nicolas. Bayer saw superior strabismus on one side with deviation of the end of the nose to the same side; but it is quite possible that the inferior strabismus of the other side, more difficult to detect, passed unnoticed; this is suggested by the fact that Clerget has seen a vertical double strabismus in a horse, superior on one side and inferior on the other, the latter being more marked and a deviation of the head directed by the inferior strabismus. Webb, A.V.C., records a case of double oblique strabismus in a mule; the head, when looking at an

* Dollar, *Veterinarian*, 1896, p. 393.

object, was held towards the breast, and both eyes were turned inwards and downwards.*

The deviation of the head is a secondary symptom depending on the strabismus, or at least this seems to be proved by the following fact: Ballangée observed a spontaneous strabismus in a horse accompanied by deviation of the head; some months later the two symptoms disappeared simultaneously.

Fig. 165. Deviation of the head and asymmetry of the face in left inferior strabismus.

In the dog Gray has found the deviation of the head to precede the strabismus; in some of his cases the cause was traced to cerebral tuberculosis; in others to the after-effects of distemper. In the latter case, it is sometimes associated with vertiginous or pivotting round in a circle movement when the animal commences to walk; these associated conditions may continue the whole course of the animal's life. In some of the apparent cases of torticollis associated with squint in the dog, the neck cannot be straightened.

In a fowl showing a paralytic strabismus consequent on a traumatism, Larcher also observed a deviation of the head which might be considered as an exaggeration of the normal deviation necessitated by monocular vision (*See* p. 311).

(2) *Facial asymmetry*. Amongst connex symptoms *asymmetry in position of the orbits* is also seen, the orbit of a strabismic eye being lower than the other

* E. Clive Webb, *Journ. Comp. Path. and Therap.* 1907, p. 337.

if the strabismus is inferior, and higher if it is superior. *Asymmetry in the direction of the ears.* In this the ear corresponding to the strabismus is turned towards the same side as that to which the eye is deviated. *Asymmetry of the palpebral fissure.* In this the upper lid also follows the direction of the deviation of the eye.

(3) As to the *state of vision* in strabismus we know but little, except that in the cases in which the pupil is found more or less completely hidden, the vision is diminished to a corresponding degree.

Besides these exceptional facts, the information on this point is very vague. The horses seen by Peters and Bayer were considered to be seeing badly. In Ballangée's case the animal showed a tendency to turn towards the side on which the eye was deviated and to graze the walls of the stable on this side as if he could not see them.

Etiology. Knowledge on this point is most rudimentary.

Congenital strabismus. Seen in the horse by Clerget, Fayet and Nicolas, in the ox by H. Koch, Dexler, Brissot, and Nicolas, in the dog by Vachetta, and Gray, in the cat by Gray, and in the rabbit by Dor, this is sometimes double, sometimes horizontal and then always convergent, sometimes vertical and then it is especially inferior, but may be superior. The convergence may be so marked that the pupil is completely hidden in the internal angle and the animal is blind (Koch, Nicolas). In one of two horses showing double convergent strabismus seen by Nicolas, the deviation coincided with a somewhat frontal position of the eyes which were very mobile and fixed straight forwards.

Amongst the first causes of strabismus Dexler has reported the lengthening, diminution in thickness and pallor of one of the recti muscles.

Cases in which the strabismus is accommpanied by facial asymmetry should, without doubt, be referred to congenital malformations of the bones. Curvature of the head from one side to the other, and asymmetry of the orbits, have also been met with by Morot in a fœtus removed from a mare, at

full term; but the position of the eyeballs in the orbits was not determined.

In a rabbit which showed a vertical congenital strabismus, which was non-paralytic, movements of the eyes were made in all directions, and on post mortem examination Dor found an *atrophy of the cerebellum.*

Brissot has reported a case of inferior strabismus in the cow which was hereditarily transmitted. Every member of a litter of pups or kittens may be affected with convergent squint, which in the Siamese cat is apparently a normal characteristic. In congenital squint there are often other congenital defects of the eye or other parts of the body. In congenital superior vertical squint affecting both eyes, which may be seen in every member of a litter of pups, the animal runs with his nozzle inclined upwards, so that the facial surface is almost on a level with the upper surface of the neck.

Strabismus from mechanical causes. Cicatricial adhesions of the conjunctiva to the eyelids may cause strabismus; but it is more especially tumours of the orbit which are responsible for this condition. In these cases the strabismus may be in any direction and is usually accompanied by exophthalmos and other symptoms of orbital tumours.

Strabismus from muscular paralysis. Paralysis affecting the eye may depend on a lesion of the muscle or of the motor nerve. The seat of the lesion may be orbital or intracranial.

Orbital paralysis may be due to a traumatism affecting and rupturing the muscles or the nerves as in observations by Stockfleth, and Möller in a dog; or to compression by a tumour, an angioma for example, as in a case reported by Zschokke in a cow in which the nerve to the external rectus was atrophied by the neoplasm.

Intracranial paralysis is caused by lesions attacking the nerve trunks at the point at which they enter the bony canals at the base of the cranium, their bulbar roots, their nuclei or their cortical centres.

In a horse a fracture of the basilar hypophysis was responsible for this condition from the animal running

back breaking the halter shank and falling on the head (Payrou) ; discrete hæmorrhagic lesions on the surface of one hemisphere, following on commotio cerebri, in another case (Arloing); in a dog which fell about a metre and sustained a hæmorrhage from the anterior cerebellar artery causing lesions which led to the degeneration of the posterior corpora quadrigemina and of the middle cerebellar peduncle (Lesage). In Dollar's case, in a 11 year old gelding, there was a tumour present on the left lobe of the cerebellum and hæmorrhages at the central line of the cerebellum above the fourth ventricle and in the vicinity of the corpora quadrigemina.

It may also arise in a dog from hæmorrhages and foci of softening situated on the anterior faces of the bulb and the cerebellum, and consequent on distemper (Liénaux); a sarcoma compressing the bulbo-protuberantial region (Hébrant); in sheep, lesions of meningitis, and of the cystic stage of tænia cœnurus, in the anterior, lateral and posterior parts of the brain, as well as in the cerebellum (Delmer); in cows, the lesions of tuberculosis at the base of the cerebellum, and in the lateral and inferior parts of the isthmus (Hamoir, Moussu). Strabismus is in the majority of instances in animals symptomatic of some congenital defect of, or of some lesion in, the brain, set up by tuberculosis, rabies and other infective or toxæmic diseases. It is also seen in morphine and other narcoses in the dog; in morphine narcosis for the purpose of surgical intervention the eyeballs are turned obliquely inwards and downwards, and the front of the eyeball is covered by the raised membrana nictitans. If the animal is roused from its stupor these phenomena disappear.

Diagnosis of the cause of ocular deviation. This is much less simple than it may appear. It has first to be considered whether the strabismus is paralytic or non-paralytic. In paralytic strabismus the eye only makes movements in the field of action of the muscles which are not affected, whilst it cannot move in the direction governed by the paralysed muscle or muscles. Thus, suppose the inferior rectus is paralysed:

this will allow the superior rectus, the action of which will no longer be counter-balanced by the inferior muscle, to deviate the pupil upwards; the eye will move inwards and outwards and also upwards, but the pupil cannot be lowered.

If, on the other hand, the strabismus is not paralytic the movements of the eye will be possible in all directions starting from the position of strabismus, and allowing that they are not hindered by any mechanical cause.

The discovery of deviation of the eyes may therefore raise a suspicion of paralysis; but the absence of movements in one direction or the other *only*, allows a diagnosis to that effect to be made.

Now, in man, movements of the eyes can be commanded at will, but in animals this has to be done by artifice; in the dog the movements of the eye may, to a certain extent, be induced by a piece of sugar being held before the eye.

In the other animals the observation of spontaneous movements must be relied upon; these are sufficiently extensive in a horizontal direction to allow of useful information being obtained from them; they are very limited in a vertical direction and thus a new difficulty is added to those already existing.

The first diagnosis being made, the *seat of the lesion* must be sought for.

Isolated ocular paralysis is most commonly peripheral in origin, multiple paralysis, on the other hand (*ophthalmoplegia*), being more often central. In the latter case it is accompanied by paralysis of other motor muscles, of the face or of the limbs, allowing the seat of the lesion to be clinically fixed more definitely. Thus, in a dog attacked with locomotor ataxy Hébrant found a right ophthalmoplegia, right facial paralysis and left hemiplegia. The alternation of these symptoms of paralysis can be explained by referring to diagram 164, and it may be mentioned that the author above named found, on post mortem, a tumour showing the histology of a sarcoma, about the size of a small pea on the

right side of the bulbo-protuberantial region and compressing the corresponding nervous centres.

Moreover, *the nature of the lesion* will be determined, if possible, by the examination of the conditions which have led to the development of the strabismus. Lastly, in every case of strabismus suddenly appearing without apparent cause in aged animals, tuberculosis should always be suspected, and, therefore, the tuberculin test should be applied.

Treatment. Counter-irritants applied to the region round the orbit, the internal administration of iodide of potassium and subcutaneous injections of pilocarpine (2 grammes, Ballangée), are among the therapeutic measures which have been employed. It does not seem possible that in cases of non-paralytic strabismus that the surgical means used in man by the advancing of the insertions of the muscles into the sclerotic could be applied.

Operative Treatment. In consequence of the conditions under which strabismus appears in animals, the methods of dividing or advancing of one of the ocular muscles, chiefly the internal or external rectus, adopted in human ophthalmology rarely, if ever, give satisfactory results in animal practice.

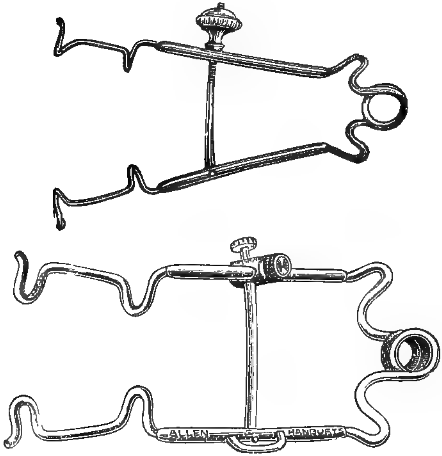
Tenotomy. This is performed with the object of dividing the tendon close to its insertion into the sclerotic. For this operation the following instruments are required: Eye speculum, blunt pointed scissors, straight or curved on the flat, serrated fixation forceps and two strabismus hooks.

The scissors should be of the best quality and capable of cutting well at the points.

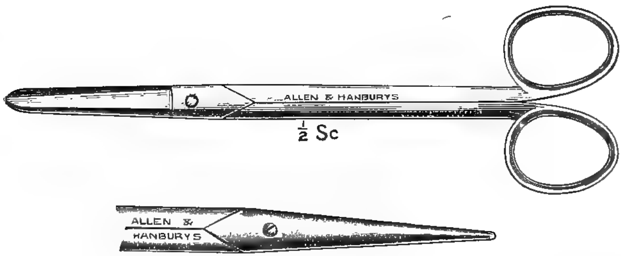
The eye should be anæsthetized by a subconjunctival injection of cocaine or novocain with adrenaline made at the point to be operated upon. If the animal should be restless, so that the movements of the eye and head are difficult to control, general anæsthesia would be advisable.

In convergent squint the internal rectus is divided; in divergent squint, the external rectus.

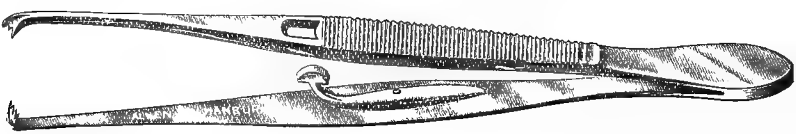
The conjunctival membrane over the muscle to be divided, is pinched up with the forceps, either in a vertical or horizon-



Eye specula.



Scissors.



Fixation forceps.

Strabismus hook.

tal direction and divided with the scissors, so that a conjunctival wound taking the direction of the width or length of the muscle remains; Tenon's capsule is penetrated below the tendon and then a strabismus hook is introduced and passed by a sweeping movement under the tendon, which is drawn forward, and either it or the muscular substance is divided with the scissors. The second hook is used for searching for any small strands of tendon that might be likely to have escaped division. Incomplete division of the tendon or the muscle would nullify the object of the operation. The conjunctival wound can either be sutured or left alone. Tenotomy (*strabotomy*) acts by allowing the divided muscle to become adherent to a spot more posteriorly situated on the sclera.

Advancement. In this operation for horizontal squint the contracted rectus is divided as described above and the lengthened rectus is exposed and taken up and held in the strabismus hook, while a needle carrying fine silk is passed from its upper margin between the tendon and sclerotic and then through the tendon at its middle line. Another suture is passed in a similar manner behind the tendon from its lower margin, and through it close to the first suture. Both sutures are tied firmly on the tendon, leaving a long end to each. The tendon is separated from the sclerotic close to its insertion with the scissors. The sutures are then passed through the band of conjunctiva between the opening and the cornea, which had previously been separated from the sclerotic, and tied. In consequence of this, the insertion of the muscle is advanced to the sclero-corneal limbus.

Nystagmus. This term is used to designate involuntary, short, jerky movements of the eyes which are repeated more or less rapidly and always in the same direction. These movements may take place in a vertical or in a horizontal direction, moving like a pendulum (*oscillatory nystagmus*); or the eye may make rotatory movements round its antero-posterior axis (*rotatory nystagmus*); but these two movements

may also be combined (*mixed nystagmus*). Nystagmus is most commonly bilateral.

In animals it has several times been attributed to poisons; chloroform narcosis will also determine the condition. Siedamgrotzky saw it in a pig following on poisoning with herring brine. It is commonly seen in the cat when suffering from auricular (symbiotic) acariasis and also from ataxia. In paralysis of the vestibular nerve, horizontal nystagmus towards the sound side with conjugate position of the eyes is frequently observed in dogs, cats, pigs, rabbits and birds, probably affected with auricular acariasis or catarrh.

In other cases the cause seems to be some alteration in the cerebrum or cerebellum. Johne has seen it in the horse in cerebro-spinal meningitis, Möller in young dogs affected with congenital blindness and microphthalmos, and Liénaux also in the dog after distemper, which, beside double nystagmus, showed paralysis of the ocular muscles and of the limbs; one recovered on being treated with iodide of potassium. In the dog Gray has frequently found nystagmus without any other muscular disturbance following on distemper; he has also seen it associated with chorea, meningitis, hydrocephalus and after convulsions. Dr. Dor studied a rabbit which was suffering from congenital cerebellar atrophy, and showing rotatory nystagmus on one side and oscillatory on the other. Other cases recorded by Storch, and Ogilvie in the cow, and by Leisering in the dog have not been ascribed to any certain cause. Nystagmus is often seen during an epileptic seizure, hysteria, in convulsions, or in the death agony in all species; in the cow in parturient apoplexy. In the larger animals it is often termed "pirouetting of the eyeballs."

It is not infrequently observed in several members of a litter of intensely inbred pups, in which in may sometimes disappear spontaneously.

By provoking cerebral anæmia by the ligature of the cerebral arteries in animals, Knoll has seen nystagmus develop, and disappear with the anæmia, but it recurs again when the sensitive nerves are stimulated. It may be that the

nystagmus seen by Vachetta when introducing air into the veins to study gaseous embolism was due to anæmia. In man it occurs in albinos and commonly in miners; in the former it decreases in intensity as adult age approaches, and may sometimes be associated with similar movements of the head during reading or the performance of some interesting work requiring close attention of the eyes.

CHAPTER XVI.

OCULAR THERAPEUTICS AND FORMULARY.

It may be useful to collect together the therapeutic agents and formulæ generally used in the treatment of eye diseases.

Therapeutic agents are applied to the eye in the form of collyria, guttæ, fomentations, ointments, oils, gelatin discs or lamellæ or powders.

Collyria, or eye washes, are generally applied to the external surface of the eyelids or introduced into the conjunctival sac by means of a spray, syringe, douche, piece of sponge, or a pad of lint or cotton wool. When of small bulk and containing expensive alkaloids or alkaloidal salts, they are termed *guttæ* or *drops*, and are instilled into the conjunctival sac by means of a pipette, or eyedropper or dropping-bottle (*Vide* p. 191), or even by a small piece of lint saturated with the solution.

In the *dog* and *cat*, or other small animals, the eyelids may be drawn apart from the eyeball by the thumb and index finger of each hand of an assistant, so that a pocket is formed, and when the liquid is introduced the eyeball is in a veritable bath. When a piece of lint is used it should not touch the eyelids or the eye, but held an inch or two above these organs, and so squeezed that the fluid trickles in drops into the expanded conjunctival sac.

In the *horse*, and other large animals, one cannot generally put the head in a position that will allow the fluid to fall into the conjunctival sac. Therefore, the following procedure may be adopted: The dropping-bottle is held in the right hand for the left eye, and *vice versâ*. Whilst the other hand opens the eyelids the dropper is brought near the temporal angle of the eye, tangentially to the cornea. The animal, by this method,

does not see the instrument coming, and if he turns his head there is no danger of wounding the eye. The extremity of the dropper, being in contact with the cornea, allows a little of the fluid to run over the eye; it will flow over the surface, and is thus certain to be absorbed.

With the MacNaughton-Jones pattern of eyedropping bottle (*Vide* the extreme right-hand figure on p. 191), or a small, round, soft rubber bottle, the bulbous portion of the bottle rests in the palm of the hand, so that the fingers and thumb are left free to assist the other hand, if necessary, in separating or raising the eyelids. The warmth of the hand forces the fluid out of the inverted bottle drop by drop.

Very little fluid is retained in the conjunctival sac, so however much may be instilled, the bulk of it runs over the lower eyelid. In the case of smaller animals, collyria containing atropine, cocaine, or such like poisonous agents, should not be instilled in more than two or three drop doses, because they are liable to trickle down the lacrimal passages, reach the mouth, and become swallowed when the head is elevated, and thus set up unpleasant toxic symptoms.

Tablets containing a certain quantity of a therapeutic agent are handy in preparing extempore eye-lotions or drops.

Fomentations are often applied to the region of the eye in order to assuage pain, check inflammation, or reduce tumefaction. Either cold, icy-cold, or all degrees of warm water are used. Frequently, when hot water is used it contains some soothing or antiseptic agent, such as poppy-heads, chamomile flowers, or boracic acid. The fomentations may be applied by means of a sponge, spongio-piline, or a pad of lint or cotton-wool, for half-an-hour at the time, at intervals of one, two, or three hours. They can be maintained by fixing the absorbent material over the eye with special bandages or hoods (*Vide* pp. 107–110).

Dry cold or heat may also be maintained by the use of a Leiter tube or coil, or a small rubber bag.

Ointments are used when it is necessary to lubricate the eye, or to introduce some therapeutic agent which will act for

some time. When they are intended to act on the eyelids, they are smeared on by means of the finger or a piece of lint. If they are to act on the eye, or the conjunctival membrane, they are introduced into the conjunctival sac by a camel-hair brush, glass rod, probe, or collapsible metal or gelatine tube. The ointment applied by this method is placed under the lids, which are, if advisable, rubbed over the eyeball, so that the material is spread all over the underlying conjunctival surface. The pulp of the index finger may also be used to apply the ointment direct to the cornea. *Oils* may be introduced into the conjunctival sac by means of a pipette, or smeared on the eyelids by the finger.

When it is desired to introduce a mydriatic, miotic or anæsthetic in ointment form, the alkaloid should be used—not the alkaloidal salts, which would crystallize out.

Discs, known as *lamellæ*, and by various trade names, are prepared with gelatine and glycerine, with which is incorporated a given quantity of any of the agents commonly used in ocular therapeutics. They are economical and handy, especially for the smaller animals. One is picked up on the moistened point of a camel-hair brush and placed under the eyelid, which should be rubbed over the eyeball and kept closed until absorption has taken place. As soon as one is dissolved it may be deemed advisable to apply others until the desired effect is obtained.

Powders are sometimes blown, dusted, or flecked into the eye by means of a channelled piece of paper, spatula, camel-hair brush, or an insufflator. The chief are common salt, sugar, iodoform, calomel, oxide of zinc, and boracic acid.

Intradermic, hypodermic, subconjunctival, intraorbital, and **intraocular injections** of local anæsthetics or antiseptics are resorted to when one desires to perform an operation painlessly on the skin or the eye, or to reduce or check infection of the ocular tissues. In operations on the eyelids a local anæsthetic should be injected intradermically as well as hypodermically, as the latter method alone does not always remove sensation.

Anæsthetics.

Acoine. According to the experimental researches by Trolldenier (1889) of the Dresden Veterinary Institute, in collaboration with Dr. Hesse, this agent produces an anæsthetic action on the eye which may last some hours, but it only acts on the dog and rabbit and has no effect on the cornea of man. A .5 per cent. solution in instillations produces anæsthesia which lasts for an hour. Solutions in strength of 1 per cent. can also be used without danger, but 2.5 per cent. is caustic. Solutions of this drug must be prepared cold. It has been used in intracellular injection in eye surgery.

Acoine	.5
Cold distilled water ...	100

Adrenalin, hemisine, renaglandin, suprarenin, adnephrin, paranephrin, renostyptin, vaso-constrictine, are trade names for organic and synthetic agents having powerful vaso-constrictive properties. They also increase the anæsthetic action of cocaine, alypin, eucaine, novocain, and stovaine.

(1)	Cocaine hydrochloride ...	5 centigrammes
	Adrenalin solution (1 : 1000) ...	10 drops
	Boiled distilled water ...	5 grammes

To be injected before an operation on the eye. Used as an instillation it is invaluable in vascular keratitis, and in painful affections of the eye in the dog and cat.

(2)	Pilocarpine hydrochloride ...	5 centigrammes
	Eserine sulphate	5 ,,
	Adrenalin solution (1 : 1000) ...	10 drops
	Boiled distilled water ...	5 grammes

In hydrophthalmos and in sluggish ulceration of the cornea.

Alypin is a derivative of glycerine, and forms an ideal local anæsthetic because it is capable of being sterilized, acts rapidly, and is relatively not very toxic. It does not cause mydriasis, nor desiccation of the cornea or conjunctiva. It has a neutral

reaction, and is not precipitated by the alkaline fluids of the body. In man it does not cause intraocular tension. It may be used in a similar manner to cocaine, also in conjunction with adrenalin or suprarenin.

Cocaine does not cause mydriasis in the horse. Its disadvantage as a corneal anæsthetic is that it causes desiccation of the cornea and conjunctiva, with desquamation of the epithelium. *It cannot be sterilized, because boiling causes precipitation in solutions.* Alypin, eucaine, novocain, stovaine, and other synthetic local anæsthetics, may be used as substitutes. Solutions should be prepared just before use.

(1)	Cocaine hydrochloride ...	1
	Distilled water	100

For any painful affection of the eye, and for injection into the lacrimal passages before catheterization.

(2)	Cocaine hydrochloride ...	2.5
	Distilled water	100

In operations on the eye; if infection from the collyrium is feared, cyanide of mercury may be added to the solution.

(3)	Cocaine hydrochloride	2.5
	Solution of cyanide of mercury (1 1000)	100

(4)	Cocaine hydrochloride ...	10
	Atropine sulphate	10
	Distilled water	100

In iridocyclitis and keratitis.

Dionin. This derivative of morphine, extolled by Darier, is an anæsthetic which renders the whole eye insensitive, and its effects last much longer than that of cocaine. It also acts in the resorption of inflammatory and hæmorrhagic effusions. It has given good results in man in affections of the cornea, sclera, iris, etc.

(1)	Dionin	... ...	25 centigrammes
	Boiled water	... ...	10 grammes

Two or three drops instilled into the conjunctival sac two or three times daily, in affections of the cornea.

(2)	Dionin	... ...	10 centigrammes
	Cocaine hydrochloride	...	10 ,,
	Atropine sulphate	... ...	8 ,,
	Distilled water	... ...	10 grammes

In irido-cyclitis.

Holocaine hydrochloride may be used in a 1 per cent. solution as a local anæsthetic. Its action is prompt and lasting. It is not suitable for hypodermic or subconjunctival injection.

Novocain is a very good synthetic local anæsthetic, because it has a low degree of toxicity, is readily soluble and stable in water, and may be sterilized by heat. It is also without irritating action, and is physiologically compatible with adrenalin or suprarenin.

It is used in a similar manner to cocaine.

Stovaine is another synthetic preparation which is said to be less toxic than cocaine. It may be sterilized by heat. It must not be used even in weak alkaline solutions, because it is precipitated. It has no vaso-constrictive action. May be used for similar purposes as cocaine.

When nitrate of silver is to be used after any of the above anæsthetics, the *nitrate salt should be used.*

Subcutaneous, Subconjunctival or Intraorbital Injections.

Cocaine hydrochloride		10 – 25 centigrammes
Distilled water	... ...	10 grammes

One-half to a cubic centimetre for the dog; 1–2 cc. for the horse, injected under the conjunctiva, or under the skin of the eyelids, before operating.

Novocain or alypin	...	2.5
Suprarenin ...	...	0.00375
Sterilized distilled water	...	100

In excision of the eyeball this should be injected into the tissues in front, around, and behind the four cardinal points of the eyeball at least a quarter-of-an-hour before the operation.

Ointments.

Cocaine	Cocaine (alkaloid)	...	1
	Vaseline ...	...	100

For lubricating probes or catheters in catheterization of the lacrimal passages in the horse. (In ointments the alkaloid should be used, not the salt, as the latter crystallizes out of the greasy base).

Antiseptics.

These are used in warm solutions for bathing, instillation or fomentation in suppurative conjunctivitis and keratitis, especially where the membranes are very much swollen; for injecting into the lacrimal passages; and for disinfecting the seat of operation in surgical intervention.

Argyrol contains about 30 per cent. metallic silver and is soluble in all proportions of water, in which it keeps very well. It has been highly lauded as a sedative antiseptic in suppurative conditions of the eye in 5 to 50 per cent. solutions, instilled every three or four hours. It does not react with a soluble chloride. Comparative researches on the various silver compounds have shown that silver nitrate or zinc sulphate is far superior as a disinfectant, antiseptic or germicide in conjunctival infections. Argyrol has been found to have an extremely weak influence on the *staphylococcus pyogenes aureus* and other micro-organisms.

Albargin, argentamin, argonal, collargal, ichthargan hegonon, sophol and other silver compounds bearing various trade names have also been highly extolled for similar purposes, but the experience of those ophthalmic surgeons who

have given them a comparative trial indicate that silver nitrate or zinc sulphate is very much superior in effect.

Boracic acid.	Boracic acid	1 – 4
	Boiled water ...	100

This is very useful when applied hot to the eyes in the purulent conjunctivitis of distemper in cats and dogs.

Chinosol.	Chinosol	1
	Boiled water ...	1000

It is useful in corneal ulceration accompanied by purulent conjunctivitis in distemper in the cat and dog. It also forms one of the best and safest antiseptics after enucleation of the eyeball in these species.

Formalin.	Formalin	25 – 50	centigrammes
	Water	1000	grammes

This is too irritating for the eyes. It is useful for disinfecting instruments and the hands. For this purpose, however, *lysoform*, a liquid formaldehyde potash soap, is preferable; this has a high germicidal action, even in 2 to 5 per cent. solution.

Hydrogen Peroxide.

Solution of peroxide of hydrogen ...	1
Water	2

Not diluted, as a hæmostatic, by injections after enucleation of the eyeball or evisceration of the orbit. It is useful to remove scabs and discharges sealing the eyelids together. Also, for removing adherent bandages.

A three per cent. solution gives good results in diphtheritic and purulent conjunctivitis.

Mercury.	(1)	Mercury cyanide ...	.2 – 1
		Boiled water... ...	1000
	(2)	Mercuric biniodide ...	·1 – 5
		Boiled water... ...	5000
	(3)	Mercuric perchloride	1 – 5
		Boiled water ...	5000

The weaker solutions are preferable as an ordinary conjunctival antiseptic.

Potassium permanganate	... ...	.5 – 1
Boiled water	... ...	1000

Useful in suppurative and diphtheritic conjunctivitis and ulcerative keratitis.

Protargol.	Protargol	.5 – 1
	Water	20

This has been highly recommended in purulent conjunctivitis and keratitis. It has been used in all strengths from .25 up to 40 per cent. It should be prepared by rubbing the powder into a paste with water and diluting as required with cold or lukewarm (not hot) water. Thought by many observers to be inferior to silver nitrate or zinc sulphate.

Resorcin.		Resorcin	1
		Water	100
Sodium.	(1)	Sodium chloride ...	1 – 10
		Boiled water ...	100
	(2)	Sodium hyposulphite	1 – 4
		Boiled water ...	100

Subconjunctival Injections.

Mercury.	(1)	Corrosive sublimate	.5
		Sodium chloride ...	10
		Boiled distilled water	100
	(2)	Mercury cyanide ...	.5
		Cocaine hydrochloride	.5
		Boiled distilled water	10

In serious ulcers of the cornea, acute iridochorioiditis, diffuse chorioiditis, panophthalmitis: One cc. for a dog and 1–3 cc. for the large animals, to be injected at several points at about 1 centimetre from the sclero-corneal limbus.

Ointments.

These are used in suppurative and non-suppurative inflammations of the cornea, conjunctiva and eyelids and applied as stated on p. 540.

Aristol.	Aristol	.5
	Vaseline	10

Iodine.		Iodine	1
		Oleic acid	10
		Vaseline	40
Iodoform.		*Precipitated* iodoform	.2 – .3
		Vaseline	10
Mercury.	(1)	*Sublimed* calomel	1
		Vaseline	10
	(2)	Red oxide of mercury	1
		Vaseline	100
	(3)	Yellow oxide of mercury	1
		Vaseline	100
	(4)	Yellow oxide of mercury	1 – 5
		Atropine (alkaloid)	.2 – .5
		Vaseline	100
	(5)	Yellow oxide of mercury	1
		Cocaine (alkaloid)	1
		Vaseline	12

The yellow oxide of mercury should be freshly precipitated and the ointment made up in the dark, so as to avoid grittiness and decomposition which often cause undue irritation of the parts to which it is applied. Pagenstecker's ointment is 4 per cent., but ointments of 1.25 to 10 are also used.

Nitrate of mercury or citrine ointment (B.P.)	1
Vaseline	10

In the preparation of eye ointments some authorities recommend lanolin, or lanolin and vaseline together in various proportions. When mercurials are being applied to the eye iodine or its salts should not be given internally, and *vice versâ*, because these agents enter into combination and form on the conjunctival membrane biniodide of mercury, which sets up great irritation.

Protargol.	Protargol	1
	Vaseline	100
Salol.	Salol	1
	Vaseline	100

Powders.

These should be amorphous or impalpably fine. They are used in suppurative inflammations and sluggish ulceration of the cornea, and their consequent opacities. Care should be taken that there is no underlying iritis. Aristol, boracic acid, calomel, sugar, salt, iodoform, iodol or sulphate of soda are used as insufflations.

	Sublimed Calomel	
	Sugar	equal parts
For opacities.		

Astringent Collyria.

For catarrhal and purulent conjunctivitis.

Alum.	Alum	1 – 2
	Water	100
Borax	Borax	.5 – 1
	Water	10
Copper.	Sulphate of copper	.2
	Water	100

Useful in chronic conjunctivitis. It is sometimes prescribed in a glycerin solution or as a 5 per cent. ointment. Oleate of copper is also used for the same purpose. Cuprol, a combination of copper and nucleinic acid, which in a 10 per cent. solution, is said to cause very little pain or irritation.

Lead.	Liquor plumbi subacetatis (B.P.)	.4 – 1.5
	Distilled water	200

In order to prevent incrustrations this should *not* be used unless the epithelium of the cornea is sound. It is useful in chronic purulent conjunctivitis and in inflammation of the eyelids. From 10 to 25 per cent. of the distilled water may be replaced by rectified or methylated spirit. It is useful in œdematous and inflammatory tumefaction of the eyelids.

Zinc.	(1)	Zinc chloride	.2 – .5
		Water	100
	(2)	Zinc sulphate	.2 – 2.5
		Water	100
	(3)	Zinc sulphate	1
		Borax	20
		Water	600
Tannin.		Tannic acid	1
		Water	100
Quinine.	(1)	Quinine bisulphate	.5 – 1
		Water	100

In diphtheritic conjunctivitis.

(2)	Quinine bisulphate	.5
	Boric acid	2
	Water	100

In purulent ophthalmia, hypopyon and keratitis.

Astringent Ointment.

Zinc oxide	.5 – 1
Vaseline	10

To be applied to the surface of the eyelids in excoriation and ulceration due to discharges, etc.

In the treatment of conjunctival affections one should not confound them with iritis, as the treatment usually adopted for the former would, if applied to the latter, be disastrous in results.

Caustics.

Collyria.

Silver Nitrate.	Silver nitrate ...	.5 – 1
	Distilled water ...	100

Two drops, once a day only, in purulent conjunctivitis. In rebellious purulent conjunctivitis of long standing, as much as a six per cent. solution may be applied to the palpebral conjunctiva, care being taken that the conjunctival sac is

washed out with a solution of salt as soon as the silver salt has had its effect. When local anæsthetics are going to be used before the application of nitrate of silver, the nitrate salt of the alkaloid or synthetic preparation should be used. Nitrate of silver solutions should be kept in glass-stoppered, amber coloured bottles in order to prevent decomposition and the consequent black deposits.

Protargol.	Protargol	...	4–8
	Distilled water	...	100

In purulent conjunctivitis, accompanied by corneal lesions. (Lagrange).

Nargol, a combination of silver and nucleinic acid, is used for similar purposes and has similar action.

Pencils or Crystals.

Nitrate of silver. This is used in pencil form for touching progressive corneal ulcers, to repress exuberant granulations, notably those in epizoötic keratitis in cattle and sheep, small warts on the eyelids, etc. Mitigated solid nitrate of silver pencils are made by the fusion of one part of nitrate of silver and two parts of nitrate of potash. These are used in conjunctival granuloma and purulent ophthalmia.

Sulphate of copper. A crystal or pencil of sulphate of copper is applied to the granulations in granular conjunctivitis in the horse (Quérand), and in the dog. For a similar purpose *Lapis Divinus* is used. It is composed of one part each of sulphate of copper, alum, and nitrate of potash fused together.

Topical Caustics.

Arsenious Acid.	White arsenic	...	...	5
	Gum arabic	...	...	5
	Simple cerate	...	...	10

This is applied in a thin layer to warts (Hertwig) after having removed the horny layer. Arsenic also answers very well on

the epitheliomatous growths around the eye in man. *Care must be taken in its application*, else extensive destruction of the sound skin is likely to ensue.

Mydriatics.

Collyria.

Mydriatics are either used as aids to examination or as therapeutic agents.

For *assisting in examinations* it is customary in man to make use of agents of which the action is mydriatic, for by paralysing the accommodation they produce a very disagreeable hindrance to vision which it is best to get rid of as soon as possible. Such agents, having an *ephemeral* or *temporary* effect, are homatropine, ephedrine, mydrine, euphthalmine, eumydrine, methylatropine and cocaine.

Accommodation in animals being very limited, the mydriasis does not embarrass their vision and so atropine, which is lasting in its effect may be used without causing them any inconvenience. Hundreds of cavalry horses, into one or both eyes of which atropine has been instilled by Nicolas, have been able to do their accustomed work without any inconvenience.

In those animals such as the horse, ox, sheep and pig having the long axis of the pupil in a horizontal direction the mydriasis is especially marked in a vertical direction; in those like the cat having a vertical slit, the dilatation takes a horizontal direction, whereas in those like man and the dog having a round pupil the mydriasis is circular. Its action is more prompt in man, dog and cat than in the horse and ruminants. In the former animals the maximal dilatation is obtained within 20 to 25 minutes; and in the latter, only after the elapse of 35 to 45 minutes. When introduced into one eye only the corresponding pupil dilates whilst that of the opposite eye contracts. It has not much effect in the rabbit and none at all in birds and reptiles. In the bird, nicotine acts as a mydriatic.

Atropine.	Neutral sulphate of atropine	1
	Distilled water	200

This solution gives a maximal dilatation in about 45 minutes in the horse.

There is only one case in which the instillation of mydriatics might cause inconvenience, and that is that it may be taken for a pathological symptom in a horse examined for sale before their effects have had time to pass off. Such effects may, on an average minimal time, last five or six days, or extend to a fortnight or a period even reaching 25 days. Under these circumstances, it is advisable, to use one of the agents mentioned above, to which objection might be taken on account of their high price.

Cocaine is too slow and uncertain in action. According to Roepke a 5 per cent. solution is without effect on the horse.

Amongst the others the best are ephedrine, homatropine, and eumydrine.

Ephedrine and *Homatropine.*

Ephedrine hydrochloride	1
Homatropine ...	.01
Distilled water ...	10

According to the late Dr. Joseph Bayer, this mixture produces in the horse, a dilatation which commences six to twelve minutes after its instillation and is complete in thirty-five minutes. Four to six hours later the pupil has regained its normal appearance. Ephedrine, even in a 10 per cent. solution, has, according to Roepke, no action in the horse.

Eumydrine.	Eumydrine	1
	Distilled water ...	100

In the horse dilatation commences in twenty to twenty-five minutes after its instillation, is at its maximum (21–22 mm.) from an hour and a quarter to an hour and three-quarters and disappears two or three days later. It should be stated that eumydrine, like homatropine, still allows a certain amount of

pupillary reaction. But examination of the eye is not sensibly embarrassed (Roepke).

As a therapeutic measure, in keratitis and uveitis only those mydriatics which have a prompt and *lasting* or *persistent* effect should be used. Such are atropine, scopolamine and duboisine. They should, however, be avoided in increased intraocular tension.

Atropine.

Atropine sulphate	...	1
Cocaine hydrochloride		1
Distilled water	...	100

In instillations, four or five times daily.

Scopolamine (hyoscine) hydrobromide.

Scopolamine hydrobromide		.5
Distilled water	...	100

Half per cent. of this has more lasting effects than a one per cent. of atropine (Roepke), but is double the price of that of atropine. In iritis or in surgical intervention in which it may be necessary to obtain prompt action, preference should be given to scopolamine. A quarter per cent. solution instilled repeatedly gives a satisfactory effect.

Duboisine, which is identical chemically with, and physiologically similar to hyoscyamine acts more promptly and longer than scopolamine, but its price is four times higher than atropine.

Ointments.

These should not be used as aids to examination, because they disturb the transparence of the cornea. They are, on the contrary, very useful in the treatment of disease, for they maintain their mydriatic action by being longer in contact with the conjunctival mucous membrane, which allows of more absorption. They may be adopted in simple corneal ulceration without vascularity or sloughing.

(1)	Atropine (alkaloid)	...	1
	Vaseline ...	...	100

(2)	Atropine (alkaloid)	...	1
	Cocaine ,,	...	.5
	Vaseline	...	100

In iritis, every four hours for three days, then omit the cocaine.

Atropine slightly lowers tension of the healthy eye and only increases it when there is already an increased tension, as in hydrophthalmos.

Miotics.

Collyria.

Miotics instilled during the time the pupil is under the influence of a mydriatic remain without effect, whereas a pupil contracted by a miotic is dilated by a mydriatic. The mydriasis of cocaine is, however, overcome by a miotic such as eserine or pilocarpine. Cocaine stimulates the nerve filaments of the dilator membrane, and the miotics those of the sphincter. In the eye free from abnormal tension it slightly increases intraocular tension. After the effects of a mydriatic have passed off, miotics, however, may be used to advantage, in order to constrict the pupil in certain iridic adhesions.

Eserine.	(1)	Eserine sulphate	...	1
		Distilled water	...	100

Such a solution when instilled into the conjunctival sac contracts the pupil to such a degree that one can scarcely see any pupil. The salicylate salt, 1 : 150, may be used.

In the horse its miotic effect is obtained in 25 to 35 minutes; in the dog in 10 to 15 minutes. Its action lasts on an average for 3 to 48 hours. It acts as a miotic only when introduced into the eye. It has not any action in birds. When introduced systemically into mammals it causes a dilatation of the pupils.

(2)	Eserine sulphate	...	1
	Pilocarpine nitrate	...	1
	Distilled water	...	200

In peripheral ulceration or traumatic perforation of the cornea. Also in certain obstinate cases of ulcerative keratitis.

in the cat and dog. In hydrophthalmos, and in general in any case where the intraocular tension is increased. Eserine in 1 : 1000 solution is very efficacious in sloughing, infective and vascular ulcerations of the cornea, which are not benefited by the use of atropine. It may also be used in the form of an ointment:

(3)	Eserine (alkaloid) ...	1
	Vaseline	100
(4)	Eserine (alkaloid) ...	1
	Yellow oxide of mercury	4
	Vaseline	100
(5)	Eserine (alkaloid) ...	1
	Olive oil	100

In sluggish corneal ulcerations or opacities.

Arecoline.	Arecoline hydrobromide	1
	Distilled water ...	100

In the treatment of eye complaints in the cat with alkaloids or their salts, great circumspection must be made, because this creature is so susceptible to their toxic effects. They must neither be administered in too great a bulk, nor too great a degree of concentration. So that the animal does not absorb too great a quantity of the highly toxic agents, it is advisable to apply them in the form of lamellæ, as prepared for man. In the case of surgical intervention where an anæsthetic is required, a general anæsthetic, such as chloroform, is, in more respects than one, far preferable and less dangerous than the local anæsthetics, or even the general ones introduced subcutaneously or subconjunctivally. The dog is not quite so susceptible, but then it should be remembered that the body weight of dogs varies according to the breed, from 2 lb up to 200 lb. Cats vary from 2 lb to 10 lb, but they may reach as much as 30 lb.

It must also be remembered that certain dogs and cats are not exempt from the irritative effects of atropine or eserine on the conjunctival membrane. Furthermore, it should be noted that atropine is not without danger to the horse, if we

can believe Bonvicini, who recorded a case in which one gramme of ointment containing .5 per cent. of atropine, when applied to the eye caused a suppression of secretion, false deglutitions (gulpings), gangrenous broncho-pneumonia and death. Morphine is the antidote to atropine poisoning.

Various Therapeutic Agents.

Iodide of potassium. Given with an alkali, preferably in the drinking water or in the food, in iridocyclitis (specific ophthalmia) in the horse (Dor). The daily dose of 20–30 grammes should be continued for eight days. This dose should be subdivided so that a portion of it is taken with each meal of the day.

It is also given as an alterative and resorbent in inflammatory conditions of the choroid, retina, optic nerve, or other structures of the eye. The dose for the horse is 5–10 grammes, for the dog .2–2 grammes.

Iodine. Weak, non-staining ointments of iodine are sometimes well rubbed on the eyelids in certain eye diseases. Tincture of iodine painted on the skin round the orbit, but so that it cannot gain the conjunctival membrane, has been recommended in the treatment of hydrophthalmos, specific ophthalmia, iritis, etc. Parogen iodi is preferable to the tincture as it does not stain and is readily absorbed.

Mercury. The strong mercurial ointment gives very good results in inflammatory conditions of the uvea, retina or optic nerve.

(1)	Strong mercurial ointment	10
	Extract of belladonna	1

It has a sedative as well as a derivitive effect.

(2)	Strong mercurial ointment	1
	Extract of belladonna	.1
	Lanolin	5

Well rubbed on the eyelids of the dog it removes the irritation of the eyelids, and vascularity of the conjunctival membrane due to eczema of the eyelids. An oleate of mercury ointment containing the alkaloid atropine may also be used for like purposes.

Pilocarpine. The sudorific and sialogogue actions of this agent have been used in affections of the retina, especially when this membrane is detached.

Pilocarpine nitrate	...	1
Distilled water	...	100

Administered subcutaneously.

Sodium chloride. Subconjunctival injections of a 4 per cent. solution of common salt 8–10 mm. from the sclero-corneal limbus act as a *revulsive* in obstinate cases of iridocyclitis and episcleritis. This solution forms also an excellent eye wash. A 14 per mille solution is isotonic with the tears.

Sodium salicylate and *aspirin* in bi- or tri-daily doses of 16–32 grammes for the horse, and .3–2 grammes for the dog, are useful in inflammatory conditions of the eye due to infectious processes.

Castor oil. Instilled into the eye it allays irritation caused by the presence of foreign bodies in the conjunctival sac. It is also an excellent lubricant and forms a base for the alkaloids (not their salts) generally prescribed in ophthalmic therapy. In making these oily collyria, excessive heat should be avoided. Purified and sterilized *olive oil* or *arachis oil* is used as a base for alkaloids or their salts in eye work.

Oleic acid. This is used in preparing ointments containing vaseline, lard or lanolin with an alkaloidal base; it is said that it prevents the alkaloid crystallizing out. It is also used in the preparation of mercurial, copper, zinc, silver, and other oleates used in eyework.

Fibrolysin. This is used in corneal infiltrations and iridic adhesions. It should be injected intramuscularly.

Setons in the region of the neck act as derivative, as do subcutaneous injections of oil of turpentine in the same region. The latter are, however, indicated in acute affections.

Leeches applied to the conjunctival or cutaneous surface are very useful in removing subconjunctival or intraocular hæmorrhage.

The Law and Regulations concerning Eye Affections in France.

The Act of August 2nd, 1884, relating to the redhibitory or returnable vices.

It stipulates:

Section 2. That for the horse, ass and mule *specific ophthalmia* is considered as a returnable vice;

Section 5. That action must be taken within thirty clear days, not including the date of delivery.

Section 7. That in order not to render any action null, the purchaser must within the period mentioned in Section 5, apply to the Justice of Peace in the district where the animal is located to nominate one or three experts, who must act in as short a space of time as is possible.

These experts must verify the condition of the animal, record all useful evidence, and give their opinion under oath.

. . . . . .

This Act is so indefinite in its aim that one should not engage in an action without sufficiently taking into account the probable result. Consequently there is reason to look upon it as non-existent.

The line of procedure undertaken by the expert, previously quite logically mapped out (*Vide* Inflammation of the Uveal Tract, p. 256), ends in the same result, because it is only in quite exceptional cases that one is able to find an acute attack, or its remains and a recurrence.

We therefore think, in all sincerity, that in putting into force this so-called protective Act, which fortunately does not impose a tax on oneself, there is more to lose than gain.

The redhibitory action never being undertaken without the counsel of the veterinary surgeons of both parties, these should endeavour to bring about an amicable settlement based on the gravity of the lesions.

To guard against risks in buying or keeping a horse suffering from serious eye lesions, the purchaser has open to him the following means:

1. Examination of the horse prior to purchase.

2. Demanding a warranty from the seller that the animal is free from eye affections.

Regulations in the French Army.

The French Army, which buys from ten to twelve thousand or more horses every year, never seeks protection from the Act of August 2nd, 1884, but it does specify in its regulations for the purchase of remounts that horses will not be definitely acquired by the State until they have been "indemnified from eye affections." Therefore, it avoids risks not only against specific ophthalmia but against any lesion that is likely to interfere seriously with vision.

Animals chosen by remount commissions are sent to the depôts, where they are submitted to a complete ophthalmic examination before they are paid for. At the Mérignac remount depôt the number of horses thus eliminated in 1898–99 reached 4 to 5 per cent., and at the Caen remount depôt, taking one year with the other, 3 to 4 per cent.

The horses sent to the remount commission of the "corps de troupe" are, under the same conditions, submitted to an examination of the eyes.

To interpret uniformly the regulations, Nicolas has proposed the following classification:

Affections temporarily rejecting a horse until recovered.

Conjunctiva. Conjunctivitis, traumatisms, new growths, dermoids.

Cornea. Keratitis, traumatisms, ectasias, tumours.

Eyeball and appendages. Generally, inflammatory conditions, traumatisms, and new growths.

Affections leading to rejection.

Cornea. Opacities generalized, or only antero-inferior (because the luminous rays most useful to the horse pass through the antero-inferior region).

Uveal Tract. Generally, any trace of acute or chronic iridocyclitis. Deposits of uvea on the anterior lens-capsule, and isolated synechiæ having feeble adhesions are excepted.
Diffuse choroiditis.
Persistent mydriasis.
Solutions of continuity.

Retina and Optic Disc. Disturbance of transparency, hæmorrhages, retinal detachments papillœdema and atrophy, total or generalized in the supero-posterior regions.

Crystalline Lens. Total or generalized lenticular cataracts.
Dense capsular cataracts.
Acquired displacements.

Vitreous Humour. Any exudative disturbance or diffuse hæmorrhage.

Eyeball and appendages. Hydrophthalmos, panophthalmitis, exophthalmos, filaria, paralysis of the orbicularis, and paralytic blepharoptosis.
Strabismus, more or less hiding the optic disc.

(*Bulletin Société Centrale Vét*, 1909, p. 481).

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ADDENDA.

Page 7. After first paragraph add:

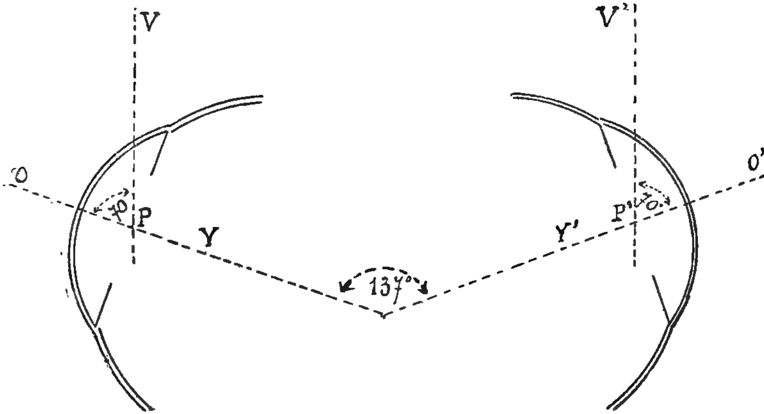

Diagram showing the Direction of the Eyeballs in the Horse.

The visual lines V and V' of the binocular vision showing that it is made by the anterior or nasal region of the cornea and the posterior or temporal region of the retina.

Page 8. Add after section on "Development of the Eye":

"Consult among other recent works on the Anatomy of the Eye, Dr. Victor Franz's paper on 'Studien zur vergleichen Anatomie der Augen der Saügetiere. *Archiv für vergleichende Ophthalmologie*, ii, Jahrgang, Nos. 6 u. 7, S. 180–217 u. 269–322."

Page 83. Last paragraph. After "Ablaire is of similar opinion," add: "which is supported by the following statistics of Neseni: Out of 37 shying horses 62 per cent. had changes in the lens; out of 470 horses which did not shy 65 per cent. also had changes in the lens."

Page 132. After fourth line from top of page add: "In the conjunctival sac of the ox Müssemeyer observed granulations of a tuberculous nature."

Page 157. At the end of second paragraph add: "and Morax in the trypanosomiases (mal de Caderas, dourine, nagana) as well as other ocular changes, such as corneal ulcers, iritis, retinitis, and retinal detachment."

Page 212. Fourth paragraph, seventh line. After (Pouchet) add: "*Vide* Plate VIIA, p. 321."

Page 277. At the end of third paragraph add: "Gray observed nodular iritis in a Welsh terrier. The pupil was amaurotic and showed the greenish reflex of the tapetum. On the anterior face of the inferior pupillary margin, inclined to the nasal angle, there were seen three spherical nodules the size of a fig seed, yellowish in colour and arranged in the form of a pyramid. Their weight evidently turned the edge of the pupil inwards and downwards. There were old streaky lesions on the anterior capsule of the lens. Probably the nodules were of a tuberculous nature, but unfortunately a complete examination was not allowed."

Page 289. Seventh line. After "disturbance of vision" add: "In a dog observed by Nicolas the coloboma of the tapetum lucidum (*Vide* Plate VIIA, p. 322) allowed the confusion of the large vessels of the choroid to be seen as distinctly as in an anatomical drawing."

Page 386. After last paragraph add: "Gray encountered a case of bilateral luxation into the anterior chamber of a fox-terrier observed some time after a fight with a cat. The pupil was apparently widely dilated, but in reality the iris was pressed back towards the fossa patellaris forming a funnel, at the deep portion of which was the pupil, having half the diameter of the "apparent pupil." The deeper portion of the iris was of a lighter colour than the darker narrow circumcorneal zone. There was no iridodonesis. There was a commencing posterior keratitis. The blepharospasm was so intense that an examination could not be made without the aid of cocaine."

Page 447. At end of third paragraph add: "In the pig, dog and cat, there are no eyelashes in the lower eyelid."

Page 448. At end of top paragraph add: "The same cannot be said for the bird, as having no glands of Meibomius there cannot be any greasy material to render the conjunctival sac impervious when the eyelids are closed."

Page 468. At end of second paragraph add: "The abnormal hairs, especially those in the lower lid, may, when they irritate the front of the eyeball, set up blepharospasm and consequently entropium."

ADDENDUM.

Action of Injurious Gases on the Eye of the Horse.

During the Great War of 1914 the Germans used against their enemies shells containing different chemical substances which had varied effects on the eyes. The *lacrymogenes*, or tear-producing gases, such as bromacetone and chloropicrine only determine lacrimation, rarely conjunctivitis, and in any case negligible effects on the horse.

The more serious are the *vesicants*, such as the bromide of benzyl, and arsine, chloride, and especially sulphide of ethyl dichloride, commonly known as "mustard-gas" because of its odour, and also as "Yperite" because it was first used against the British front at Ypres in Belgium.

Yperite produces severe tumefaction of the eyelids with ulceration and sloughing, conjunctivitis of more or less intensity, keratitis with opacity and superficial or deep ulceration, and sometimes perforation and panophthalmitis.

Protection of the eyes of horse and mule is useless in the case of lacrimatory gases, but it is called for in the case of the vesicant gases; it is afforded by a broad and thick bandage closely fitting and covering the head.

Some veterinary surgeons have suggested the use of spectacles, but the idea has not found favour in France because of the difficulty of applying them.

Serious lesions may be prevented by washing the eyes of animals having passed through the toxic zone with a 3 to 4 per cent. solution of bicarbonate of sodium or artificial serum—14 of sodium chloride to 1000 of water.

October 1918.

CORRIGENDA.

Page 5, bottom line of table under Man. *Delete* figures in second column.

Page 6, line of table under Pig. *Delete* figures of 4th, 5th, 6th and 7th column.

Page 6, line of table under Rabbit. *Delete* figures of the 1st, 3rd, 4th, 5th, 6th and 7th column.

Page 7, bottom line of table under Man. *Alter* figures of 2nd column from 42 to 42.6.

Page 11, Fig. 8. To top line *add* Hind-brain; to second line *add* Mid-brain.

Page 14, Fig. 12. Instead of Optic pedicle *read* Optic papilla.

Page 16, Fig. 16. Instead of Iridien portion of Retina *read* Iridic portion of Retina.

Page 16, bottom line. For iritic adhesions *read* iridic adhesions.

Generally in Chapter 1 for francaise *read* française.

Page 23, line 6. For focus F *read* focus F'.

" " 7. For focus *read* focus F.

" " 8. For R' *read* $R_{,}$.

Page 23, line 6 of last paragraph. For concave lense *read* concave lenses.

Page 27, last line of first table. Instead of $(S_{,}S')$ *read* $(S_{,}F')$.

Page 27, first paragraph below table, second line. Instead of H, *read* $H_{,}$.

Page 27, first line of last paragraph. Instead of cornea *read* corneal.

Page 30, line 7. After air (index equals $=1.33$ or $\frac{4}{3}$ *read* air, the index of which $= 1$ from the aqueous humour of which the index $= 1.33$ or $\frac{4}{3}$.

Page 30, line 11. Instead of *r* and *n* *read* *r* and *u*.

Page 33. The line in italics should *read* thus: "The distance of the remotum measures thus the degree of myopia."

Page 35, line 3 of third paragraph. Instead of .25 cm. *read* 25 cm.

Page 36. In third paragraph the formula

$$q = 30 \times \frac{40}{1} = 1200 \text{ mm.} = 1 \text{ m. } 20 \text{ cm.}$$

should *read* thus: $q = \frac{30 \times 40}{1} = 1200 \text{ mm.} = 1 \text{ m. } 20 \text{ cm.}$

Page 47, second paragraph, line 9. Instead of blurr *read* blurs.

Page 54, line 5. Instead of *p*, *O′*, *n*, *read p*, *P′*, *n*.

Page 56, end of third paragraph. Instead of convex lense *read* concave lense.

Page 64, line 8 from top. For calvary *read* cavalry.

Page 64, second paragraph, line 2. Instead of "to actually formulate" *read* "actually to formulate."

Page 66, line 5 from top. For principle *read* principal.

Page 68, line 6 from top. For .50 + .5 = 55 cm. *read* .50 + .05 = .55 cm.

Page 68, bottom line of second paragraph. For

$$\frac{1}{.25+.10} = \frac{1}{.35} = 3.33 \text{ D. } \textit{read } \frac{1}{.25+.10} = \frac{1}{.35} = 2.85 \text{ D.}$$

Page 70, line 7 from top. Instead of from the eye *read* in front of the eye; line 9, for front of the eye *read* behind the eye.

Page 73, paragraph 3, line 4. For *r read remotum.*

Page 75, paragraph 3, last line but one. Instead of −2D *read* 2D.

Page 84, under Astigmatism, line 5. For .75 of the eyes *read* .33 (⅓) of the eyes.

Page 112. *Transpose* "in sheep" from line 12 to line 11 after "Morano has found them."

Page 112, line 8 of second paragraph. After gland of Harder *delete* "is" and *add* , (comma).

Page 112, last line but one. After "the third" *add* "eyelid"

Page 128, last line but one of second paragraph. For antidiphtheric *read* antidiptheritic.

Page 133, paragraph 2, last line but one. For membrane nictitans *read* membrana nictitans.

Page 141, end of second paragraph. For (Deber) *read* (Leber).

Page 143, third paragraph. For Müller *read* Möller.

Page 151, second paragraph, last line but one. *Delete* "of" after "thickness."

Page 178. Instead of Müller *read* Möller.

Page 183, bottom line. For Angeurotz *read* Augenrotz.

Page 184, first paragraph, last line but one. Instead of trigemimal *read* trigeminal.

Page 193, first line following Ectasiæ of the Cornea. Instead of ectasia *read* ectasiæ.

Page 193, fourth line of paragraph commencing with Staphyloma. Instead of iridial *read* iridic.

Page 199, third line from bottom. For iridial *read* iridic or iridal.

Page 207. For Brucke's *read* Brücke's.

Page 212, fourth line from top. For Brücke *read* Bruch.

Page 213, last line but one. After "The short posterior ciliary" *add* "arteries."

Page 215, last line. For iridial *read* iridic.

Page 226, second line of description of figure. For "pa" *read* "ga."

Page 227, head line of page. Instead of "Tumours of the Cornea" *read* "Inflammation of the Uveal Tract."

Page 229, last line but two. Instead of "be" *read* "by."

Page 233, end of first paragraph. For cholestrin *read* cholesterin.

Page 239, head line. For iridial *read* iridic or iridal.

Page 262, third paragraph, line 3. *Delete* "under the conjunctiva (he also used" and *read* "(and also."

Page 269. Third paragraph, line 5. For hyphæma *read* hyphæmia.

Page 285, second paragraph, lines 2 and 3. *Read* "an heredity" instead of "a heredity."

Page 296, first paragraph, line 5. For focuses *read* focusses.

Page 308. Instead of the angle "Y" on this page *read* the angle γ (gamma).

Page 320. For Müller *read* Möller.

Page 322, first paragraph, line 4. After first word *add* "In the rabbit."

Page 341, Fig. 119. After crystalline *add* lens.

Page 360. Figure of "Cataract of Horse" is upside down.

Page 365, last line but one. For extensively *read* intensively, and in line 6 and all through the book where written Léclainche *read* Leclainche.

Page 395. Under Congenital Anomalies at the commencement of line 8 *add* "and" immediately before "the rabbit."

Page 397. In the second paragraph describing Fig. 136, instead of *n*, *n*, *read h*, *h*.

Page 416, line 2. For dessication *read* desiccation.

Page 420, last paragraph, line 9. *Add* "and" before "*F. labiato-papillosa*.

Page 436, last line of paragraph. Instead of "dilate the pupil" *read* "the dilator of the pupil."

Page 446. At the commencement of third paragraph, for scleral *read* sclera.

Page 457, last line but one of first paragraph. After "ulceration of the face" *delete* "of a cat."

Pages 469 and 470. For Mégnin *read* Magnin.

Page 479, commencement of second paragraph. For Mechanical Entropium *read* Mechanical Ectropium, and in the last line but one of the same paragraph for caruncula lacrimalia *read* caruncula lacrimalis.

Page 503, line 4. For "know" *read* "known."

Page 536, third paragraph, line 2. For "in which in may sometimes" *read* "in which it may sometimes."

Page 556, in the line between the two prescriptions at the bottom of the page. For derivitive *read* derivative.

Page 558, in the first line of second paragraph. Instead of "act as derivative" *read* "act as a derivative."

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